NATIONALGEOGRAPHIC.COM/MAGAZINE | NOVEMBER 2007

# NATIONAL GEOGRAPHIC

## Memory

### Why We Remember, Why We Forget


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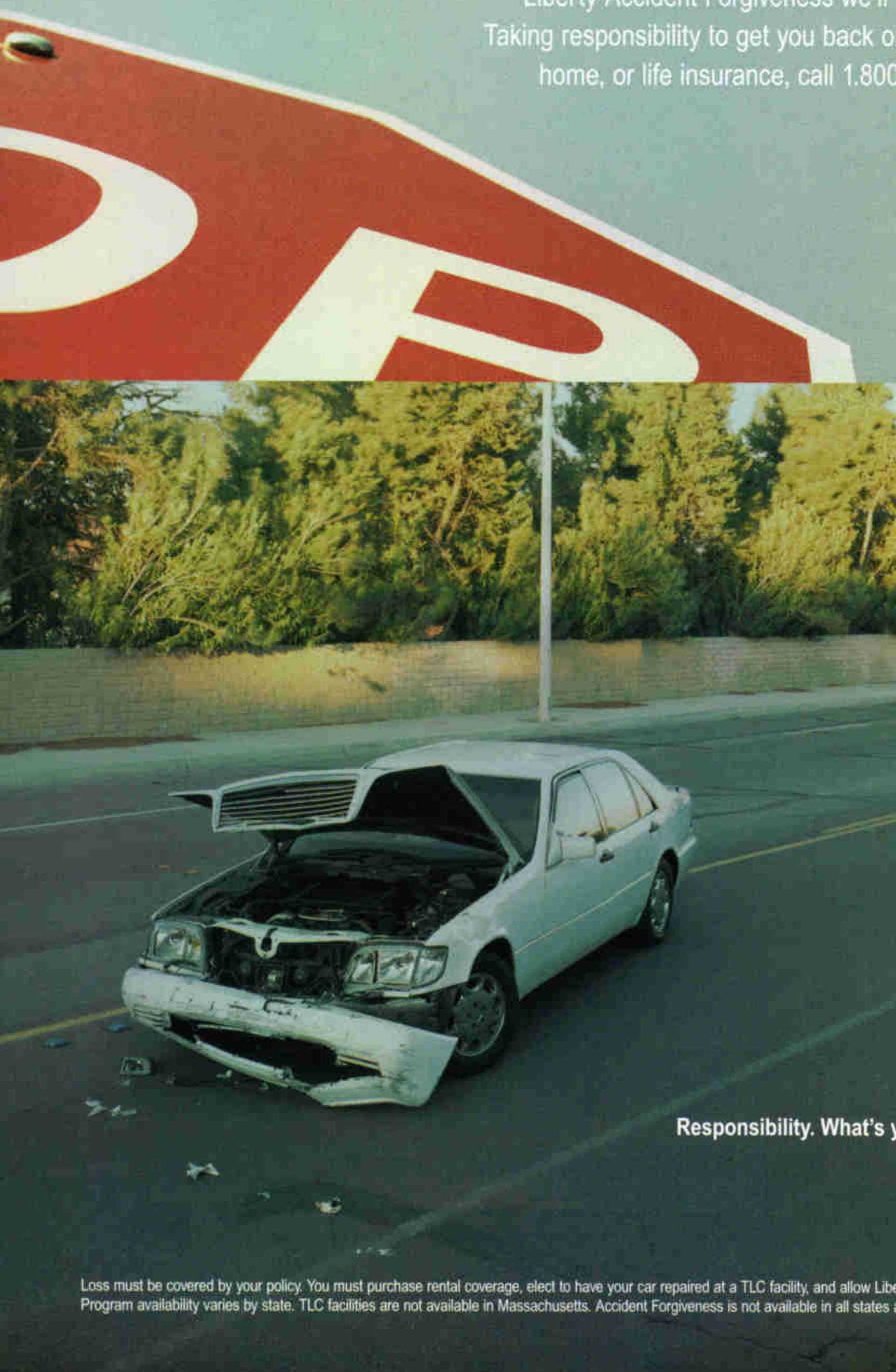

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# NATIONAL GEOGRAPHIC

NOVEMBER 2007 • VOL. 212 • NO. 5


Safe shelter: On the Tongan island of 'Uiha, a girl stands in the door of what locals call a "hurricane house"—a prefab structure donated by an Australian charity after a storm destroyed native thatched huts. Story on page 58.

AMY TOENSING

## Features



**COVER** Maggie Steber's family photos hold the memories now. Her mother, Madje, has dementia. **PHOTO BY MAGGIE STEBER AND REBECCA HALE**

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ngm.com

**Talk Back to the Editor**
Each month, Chris Johns offers his thoughts about the magazine in his Editor's Note. Now he's inviting readers to offer their point of view.

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*Think About It*

# DO 30 MILLION PEOPLE KNOW SOMETHING YOU DON'T KNOW?

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> CONTINUED at *ThinkAboutIt.com*

HYUNDAI

# EDITOR'S NOTE

**My father and I** are saying goodbye at a small airport in southern Africa. He and close friends of his have joined me in one of my favorite places, Botswana's Okavango Delta. We've always been close, but for some reason he seems especially emotional as I put him on the plane. Tears well in his eyes as he says how much he loves me and hopes we'll see more of each other. I assure him that I'll be home soon. He smiles and climbs into the plane.

Immediately I call my mother and sister and tell them that something is not right. During our safari he became easily confused. He drifted off in conversations. He seemed disengaged. One evening as we talked, Dad—a world traveler and geography whiz—couldn't remember the name of the Swiss village he and my mother stayed in at least a dozen times.

George and Joanne Johns hold their son, Chris.

My mother takes him to a neurologist for testing. The diagnosis is dementia, most likely Alzheimer's. Dad remains cheerful and positive. As often happens in these cases, my mother is the one who struggles with despair. Shortly thereafter, she is diagnosed with cancer. Six months later, she is gone.

My sister and I face the toughest decision of our lives: How to give our father the care he deserves? We find an excellent facility, three miles from my sister's home, that specializes in caring for those with dementia. At first he resists, then settles in. When I call, my father tells me he's buying a new yellow Mustang, and that he and my mother are driving over to visit this afternoon. It breaks my heart to hear his gentle voice making plans that will never happen, but then I think that if he is happy living in an imaginary world with his beloved wife, perhaps memory loss isn't such a bad thing. I accept his illness and cherish every moment with him.

Memory, perishable and enduring, is the brain's archive. It is a marvel of neuronic circuitry, as Joshua Foer explains in this month's cover story. Its loss can be cruel, but remember this: It is through memory that we hold on to those we love.

PHOTO: GLENN H. UTZ


**Maroon-fronted Parrot** *(Rhynchopsitta terrisi)*
**Size:** Length, 15.8 - 17.7 inches **Weight:** 0.9 - 1 lbs
**Habitat:** Mature pine, pine-oak and mixed conifer forests at altitudes of 6,500 - 11,500 feet
**Surviving number:** Less than 3,300

*Photographed by Art Wolfe*

# WILDLIFE AS CANON SEES IT

Actually, Polly *doesn't* want a cracker. The maroon-fronted parrot is content with a menu of pine seeds, agave flowers, fruits and acorns. Pines, in particular, are so vital to its diet that mating season is timed to coincide with the fruiting of these trees. The extremely social bird mates for life, laying eggs in early July and spending October and November fledging one to three chicks. It migrates seasonally, building nests in holes in steep limestone cliffs, but never strays far from the trees that sustain it. These forests, however, are being consumed by wildfires and agricultural and residential development. And as go the pines, so go the parrots.

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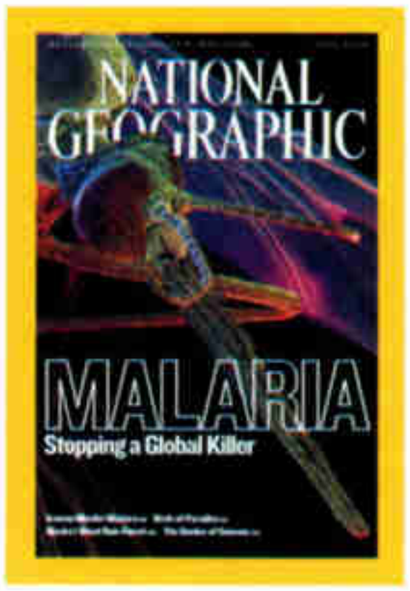
# LETTERS




**July 2007** *"Bedlam in the Blood" brought in the most mail this month. Readers remembered their own bouts with malaria, proposed solutions, and demanded help for those afflicted. "If this disease affected developed countries, much more would have been done," wrote Gail Dolson of San Leandro, California. "It's up to all the citizens of the world to speak up."*

Comment on November stories at **ngm.com**.

### Bedlam in the Blood

In Florida, mosquitoes have always been a nuisance. In fact, as I was reading the malaria article, I was bitten several times before I managed to slap the mosquitoes that must have entered the house with me. In the 1960s, I remember running outside with my brothers to watch the low-flying mosquito planes overhead. Back then we didn't have air-conditioning, and summer chores included painting our screens with an oily mixture of pesticides. At that time, we were just beginning to understand how harmful DDT was to our wildlife. Reading about Zambia's efforts to control malaria put some of that history into perspective for me. The potential threat of malaria appearing here again seems so possible and so life-changing that it is frightening.

**ANN B. TIHANSKY**
**St. Petersburg, Florida**

I would like to question Michael Finkel's assertion that DDT was used to eradicate malaria in the U.S. My research indicates that DDT was not sprayed for mosquitoes in the U.S. until 1947, and that malaria was mostly eradicated in the U.S. by then. My research also indicates that DDT was used in 1947 to prevent reintroduction of malaria from troops coming home from World War II. The U.S. banned DDT in 1972 not just because of the impact it had on wildlife, but also because of implications it had for human health. By 1972, 19 species of mosquitoes

worldwide were resistant to DDT. The poor Third World that receives DDT will have unleashed upon it a short-term gain in exchange for dreadful long-term health implications.

**NANCY MOYSIUK**
**Toronto, Ontario**

*Donald Roberts, professor emeritus at the Uniformed Services University of the Health Sciences, replies: "The U.S. started experimenting with DDT for malaria control as early as 1943. Although various control programs were successful in reducing malaria in urban areas by the mid-1940s, malaria remained a major health problem in southern rural areas. The National Malaria Eradication Program began in July 1947; almost five million rural homes were sprayed with DDT, and malaria was quickly eliminated. No meaningful adverse health outcomes to people as a result of high and prolonged DDT exposure have ever been shown. Today, developing countries that opt to use DDT will stop hundreds of thousands, perhaps millions, of malarial deaths."*

If Rachel Carson were here to defend herself, she would support the careful use of DDT in the fight against malaria in sub-Saharan Africa. *Silent Spring* was dedicated to Albert Schweitzer, the great humanitarian who devoted much of his life's work to helping ease suffering in Africa. Rachel Carson cared deeply for all of life and for generations yet unborn. Nearly 50 years ago she said clearly what is still just a glimmer in the consciousness of most people. The suffering will not begin to end until we treat the living world with the humility necessary to bring all our knowledge of its subtlety and intricacy to bear on these problems.

**MARCIA E. PHILLIPS**
**Washington, D.C.**

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# LETTERS

Just as wealth generates more wealth, poverty produces larger poverty as well. Alongside this cycle of development, there is also a vicious cycle of underdevelopment producing more misery and exclusion. This spiral is particularly corrosive when we talk about infectious diseases. If we think that Africa, with only 13 percent of the world's population, bears a burden of 24 percent of the world's disease and has only 3 percent of worldwide human resources in the health area, we can easily understand that public health in Africa has to be at the top of the world's agenda. Only through joint efforts and coordinating initiatives worldwide can we develop a partnership with Africa capable of contributing to its sustainable development. The responsibility is shared, as peace, human rights, and sustainable development are indivisible. The path is clear and there is no time to lose. Sadly, emergencies cannot wait.

**JORGE SAMPAIO**
**Former President of Portugal**
**UN Special Envoy**
**Lisbon, Portugal**

I served in the South Pacific in World War II. We had to take our Atabrine daily to keep from contracting malaria. It was a bright yellow pill and tasted awful. The medical officers must have made quite an impression on me since I took the drug faithfully and used my mosquito netting when possible. I would catch a small lizard before tucking in for the night so if there was an anopheles in with me, the lizard would get it.

**LARRY PARSONS**
**Tiltonsville, Ohio**

## The Truth About Tongass

Tongass is the largest and among the most ecologically rich of our 155 national forests. The U.S. Forest Service has been distressingly slow to adjust its management practices. Our national forests are worth far more with their trees uncut and watersheds unroaded than they are as mere tree farms. This disparity in economic value is particularly large in the Tongass, but it has been ignored by those responsible for its stewardship. In pushing for unsustainable, taxpayer-subsidized logging in its latest Tongass management plan, the Forest Service disregarded information about the economic value of clean water, salmon habitat, wilderness, and other "products" of a standing forest with intact watersheds, including carbon storage that provides a hedge against climate change. A conservative estimate of these values is 1.6 billion dollars a year. That is 50 times the total sales from forest products in all of Alaska. The Tongass should be managed for its greater values—outstanding wilderness and ecological health—that can sustain local communities for generations to come.

**SPENCER PHILLIPS**
**Senior Resource Economist**
**The Wilderness Society**
**West Charleston, Vermont**

## Corrections, Clarifications

**July 2007:**
**The Truth About Tongass** The photo on pages 104-105 shows Sitka Sound, not Favorite Channel. The map note on page 111 stating that 5.7 million acres of the Alaska Panhandle are protected by federal law is incorrect. Nearly seven million acres are protected.

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# LETTERS

We were disappointed in the incomplete picture painted of the health and economic realities of the Tongass National Forest. The story diminishes the efforts of individuals and organizations collaborating with federal land managers to resolve land-management issues. Groups such as the Tongass Futures Roundtable, with representatives from a diverse group of stakeholders, have come together to find solutions for the long-term vitality of this extraordinary place, its people and communities, and its fish and wildlife. While links on your website lead to information about these efforts, your hard copy readers will never see them. We are guided by a model of sustainability that ensures not only ecosystem integrity but also community and social viability. There are no threatened or endangered species in the forest, and we have science and sustainable practices supporting our management that includes some resource extraction for the economic stability of Southeast Alaska, as is congressionally mandated. All of this is accomplished while providing the other resource amenities the American public expects, now and long into the future.

**FORREST COLE**
**Forest Supervisor**
**Tongass National Forest**

I expected to encounter clear-cuts, but nothing prepared me for the scale of arboreal carnage I witnessed on Prince of Wales Island during my June visit. The Tongass National Forest is owned by corporate America and subsidized by the American taxpayer. A Tlingit woman told me that when an eagle finds a carcass, it will gorge until it can barely fly. How appropriate that it has become our national symbol.

**FRED JONES**
**Pilot, Virginia**

**It was probably that person who inadvertently shot him, removed the arrow after realizing his mistake, and had the unfortunate horror of watching him die from the wound.**

## Last Hours of the Iceman

I would submit that Ötzi himself pulled the lethal arrow from his shoulder, then he discarded it in anger and disgust. By the action of pulling the shaft from that location and angle on the body, he may have damaged his artery by not being able to withdraw it cleanly and at the angle of entry. If he was struck by the arrow but managed to escape and hide, then removed the shaft, cut the artery, and very quickly bled out, that would be a more plausible solution to the mystery of the valuable copper ax and other items not being scavenged.

**LOWNDES WHATLEY**
**Roswell, Georgia**

Could it be that the Iceman was a thief and was shot while trying to escape? Those pursuing him might have removed his cloak while recovering the loot and failed to retrieve the ax.

**PEDRO ESCALANTE-NÚÑEZ**
**San Miguel de Allende, Mexico**

An avid hunter myself, I am all too aware of the dangers of hunting larger game. It is highly unlikely that an older hunter would have gone to chase game at high altitude alone, because of the problem of carrying that game back to camp. He would have had at least one hunting partner with him. It was probably that person who inadvertently shot him, removed the arrow after realizing his mistake, and had the unfortunate horror of watching him die from the wound. Not quite as sensational as a border war or fights for control of the tribe, but as any hunter will tell these academic experts, it's a far more likely scenario.

**JACK MURPHY**
**Brownsburg, Indiana**

As an archer, I could not help but notice the Iceman's murderers have drawn their bows with each arrow mounted on the wrong side of the bow handle [page 77]. Otherwise Kazuhiko Sano's illustrations are wonderful and bring to life the Iceman's last hours.

**C. ROB ARMSTRONG**
**West Plains, Missouri**

*Drawing an arrow on the right-hand side of a bow is a style used by archers in various cultures, perhaps most famously in the Japanese martial art called* kyudo. *The artist chose to depict this style; how arrows were aimed in the Alps 5,000 years ago isn't known.*

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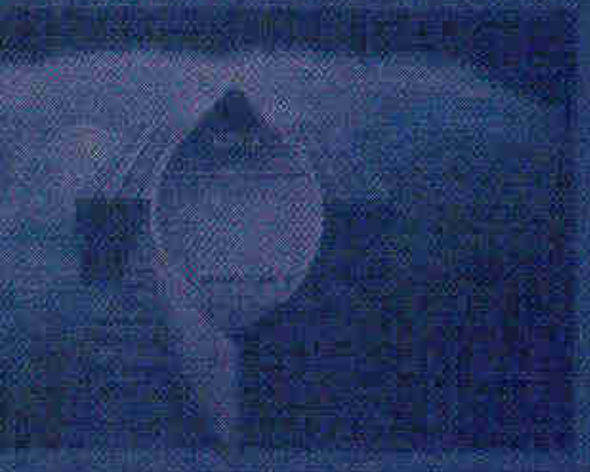

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# LETTERS

## Swarm Theory

I am of course intrigued by the commonalities of organization shown by so many organisms, including humans. Unfortunately, there may be one major difference between us and them. I think there is no question that these swarm organisms have the best interests of their groups at heart. I am not so sure that this is true of our human policymakers.

**HELEN GHIRADELLA**
**Albany, New York**

I am disappointed that you chose not to address some of the deeper mysteries of this astonishing behavior. Precision military drill teams cannot perform feats of maneuvering that buffalo do seemingly without thought. Aerobatic jets struggle to coordinate the motions of half a dozen planes, while hundreds of fish or birds can coordinate their actions instantaneously in three dimensions. If we could understand how they communicate, we could realize enormous benefits for highways, air-traffic control, manufacturing processes, and military applications—not to mention a more profound appreciation for the wonders surrounding us.

**TIMBER DICK**
**Denver, Colorado**

Peter Miller could have added a phenomenon that is observable by everyone, whether in a rural or urban environment. I have noticed that birds flock on an overhead wire or fence line in a well-organized manner. First, the flocks are almost always of one species. Second, the birds all face the same direction regardless of the direction they approach the wire. This may facilitate their next-neighbor communication. It's fun to watch the flock first land on a wire facing in both directions. Birds start hopping around to change direction and quickly select a single direction for the group. Third, spacing of these birds on a wire is amazingly uniform. One can see individuals making small adjustments in their positions to equalize the spacing. To me this speaks to the uniformity in their innate sense of optimal sharing of body heat.

**JAMES R. FRYSINGER**
**Doyle, Tennessee**

I think there is no question that these swarm organisms have the best interests of their groups at heart. I am not so sure that this is true of our human policymakers.

To compare the collective wisdom of swarm bees to the "collective wisdom" of race-track bettors is an insult to the bees. Bees work together in an evolutionary dance that inevitably leads to the best choice of a nest. Bettors, on the other hand, are solitary individuals who almost always lose, especially when they follow the collective wisdom of other bettors who decide the pari-mutuel odds. The crowd's pick, the favorite, is likely to win only 33 percent of the time, and is a losing proposition in the long run.

**KEITH KOHNHORST**
**Santa Cruz, California**

## Environment: Bottles Up!

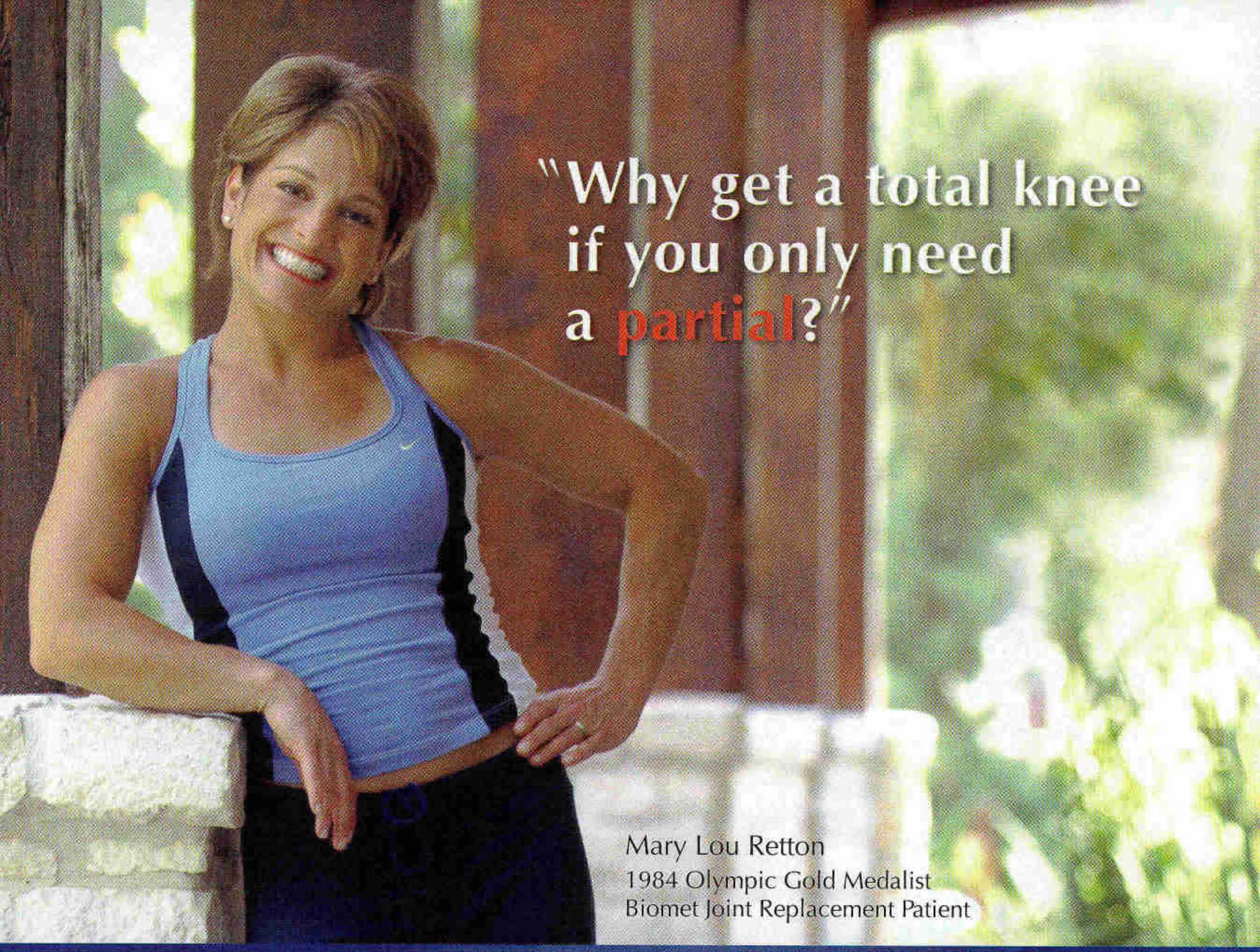
In light of your recent article on Europe's demand for bottled water, I would suggest that this issue should be taken up by governments and institutions. Our tap water is perfectly drinkable, and many people do not have a problem with drinking it. The issue is, however, that for those on the move, the easy accessibility of tap water and opportunity to refill bottles has evaporated. There need to be initiatives to reintroduce clean water fountains for public use. These water fountains would easily and very effectively reduce the plastic bottles flooding our landfills and be another step in the right direction for keeping people healthy while reducing environmental problems.

**ERIK VLEMMINGS**
**Cobham, England**

"Who Drinks the Most Bottled Water" did not mention China. During a trip to that country, I noticed that every urban area I visited lacked potable drinking water systems, which forced tourists and citizens alike to purchase water in bottles from ubiquitous vendor stands. I would think that this would push China to one of your top ten spots.

**BRIAN REITER**
**Poughquag, New York**

*China is the third largest bottled water consumer (after the U.S. and Mexico) by volume. Our map showed per capita consumption.*

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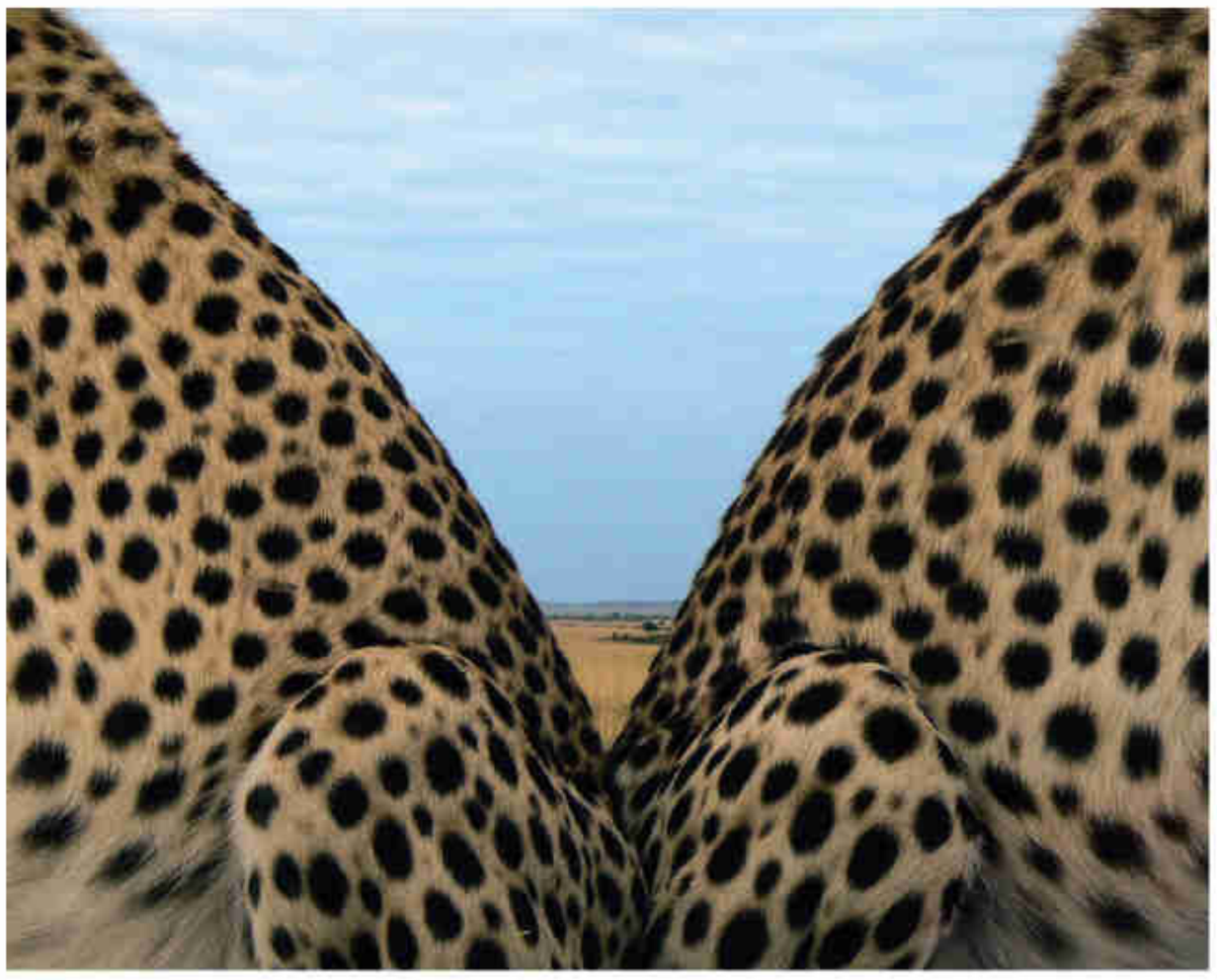
**It's a Jungle out There** This month's Your Shot selections took a hairy—and feathery, and slithery—turn as readers sent in some great animal pictures. Send us your own photos, then see how other Your Shot participants rate them with our new voting feature. New photographs are posted every weekday. For guidelines, a submission form, and more information, go to *ngm.com/yourshot.*

**Stacy Canion** Tyler, Texas

Ostriches might be flightless, but this one, at least, likes its snacks airborne. Stacy Canion, 30, caught the bird catching food pellets at the Bayou Wildlife Park near Alvin, Texas.



**Andy Flies** Lansing, Michigan

These male cheetahs sat back-to-back on the hood of Andy Flies's truck in Kenya's Masai Mara National Reserve. Later, one cheetah tried to bite off the antenna. Flies, 28, was in the region studying disease ecology of the local spotted hyenas.

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**The face of the world is changing.** Habitats are being altered by human activity, bringing often unpredictable consequences for the complex balance of life on Earth.

Protecting our remaining rain forests is important not only for reducing greenhouse gases but also for preserving their rich biodiversity, which has provided medical research with an estimated 70 percent of identified anticancer plants. Freshwater habitats are one of the planet's most important, yet most manipulated, environments. Half of the world's wetlands have been destroyed, and thousands of river miles have been dammed or diverted. At least 20 percent of all freshwater fish species are threatened, endangered, or extinct.

Hope lies with individuals, organizations, and governments who, through growing knowledge and greater understanding, are actively committed to minimizing our environmental impact in order to conserve nature's delicate harmony. To expand your knowledge visit **www.nationalgeographic.com.**

The face of the world is indeed changing, but through knowledge we can change our ways.

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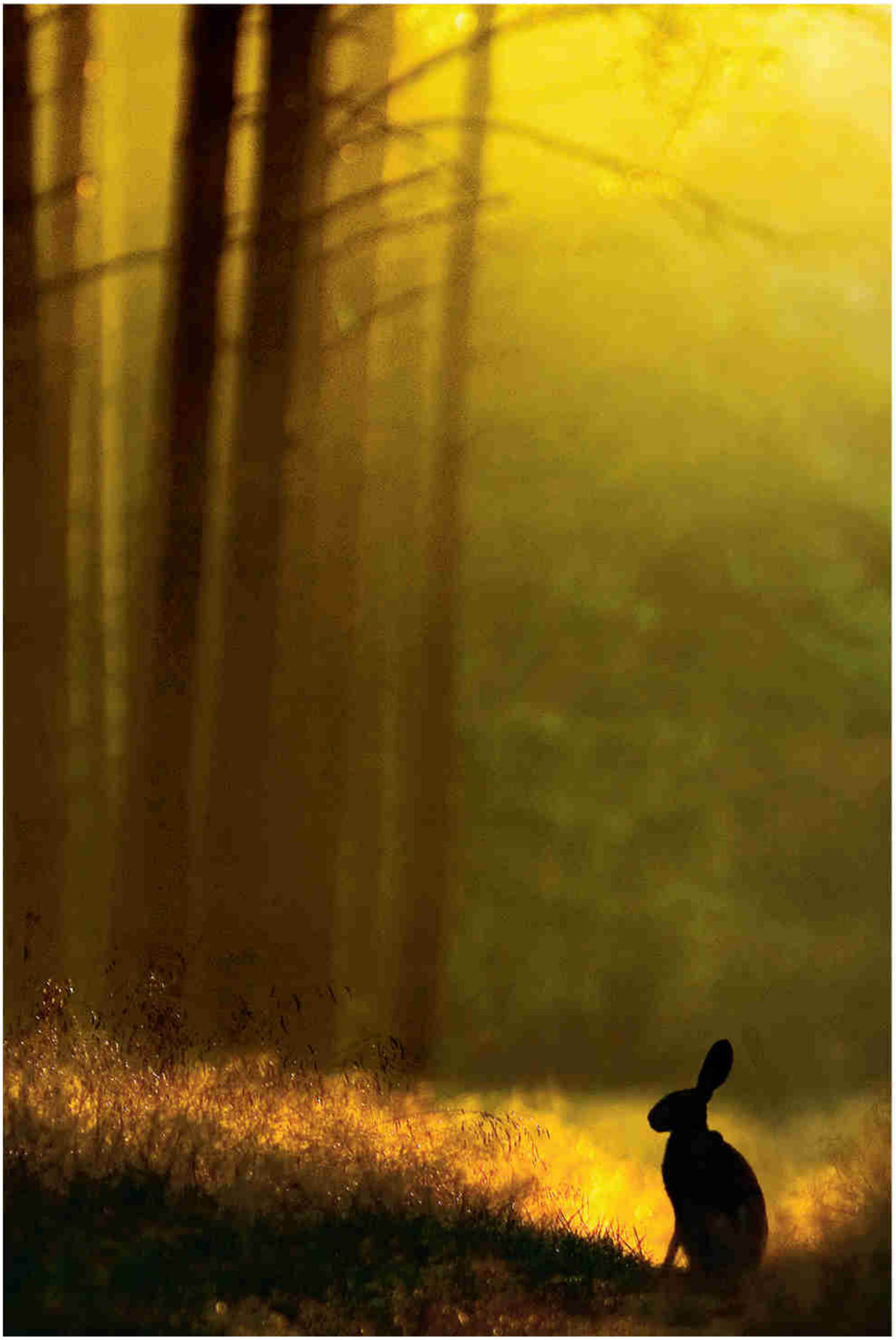

**Jerzy Grzesiak** Łódź, Poland

"The hare was only there about a minute, but for me it was ages," says 19-year-old Jerzy Grzesiak, who captured this scene during a misty dawn in Poland's Tuchola Forests. Grzesiak, an economics student, spends as much time as he can photographing wildlife.

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**Mike Guzmán**
New York, New York

It took four days for a snake to emerge from his pet green tree python's clutch of eggs. Mike Guzmán, 29, was waiting. "Babies occasionally stick out their heads and then retreat into the egg. I was lucky to photograph this one before she slid back in."

**Jonathan Nehring**
Berlin, Connecticut

First the nest set low in an evergreen caught Jonathan Nehring's eye. Then, he says, "I checked back often to see when the egg would hatch." Once it did, Nehring,18, got this shot just after the mother bird had flown to find food.


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**Sue Cullumber** Chandler, Arizona

Kasih the orangutan was trying to sleep, but her mother had other plans, says Sue Cullumber, 47, who photographed the pair at the Phoenix Zoo. "I've been taking pictures of her since she was born," says Cullumber.

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**Ian Chapman** Nottingham, England

"I don't have a great deal of time outside work to travel for my photography," says Ian Chapman, 50, who spends his days as a company director and a heating engineer. So he travels to his own backyard garden, where he specializes in shooting insects like this flower fly.

**Glynn McDonald** Runcorn, England

Retired biomedical scientist Glynn McDonald, 52, photographed this snail in a local wildflower meadow. "Snails rarely look dynamic," says McDonald. And this is about as dynamic as a snail can get.

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On trucker James Tarlton's big rig, every button, switch, dial, and knob does something crucial.

*This work appears in Kim Reierson's self-published book,* Eighteen—A Look at the Culture That Moves Us.

**On the Road, Again** I'm an excellent driver. Or so I thought. Ten minutes of steering an 18-wheeler loaded with 40,000 pounds of oranges down an interstate highway in Arizona forced me to reevaluate that belief. Maneuvers I take for granted in a car became absolutely herculean. How to describe the feeling of piloting one of these thundering weights? Imagine a 20-ton block of Jell-O in a proportionately large centrifuge. Now imagine trying to keep that mass moving in a straight line. My respect for truckers grew exponentially in those ten minutes.

I've met drivers and photographed them and their rigs at truck stops from the New Jersey Turnpike (above) to California. Maybe the fascination is in my genes: My father was a trucker. But when I was a kid, that just meant he was hardly ever around. In the five years I worked on this project, what began as personal interest grew into a sense of public mission, a desire to show people who'll never see inside a trucker's world the everyday heroism of these men and women. Long-haul trucks—hundreds of thousands on U.S. roads every day—move everything we live with. I think babies are about the only things trucks *don't* deliver.

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# PHOTO JOURNAL | KIM REIERSON

More than 30,000 people turned up this year for the Truckers Jamboree at the Iowa 80 truck stop ("World's Largest") in Walcott, Iowa. Randy Braunschweig (top) drives 48 states in his vintage truck. Long-haul Texans Mickey and George McGregor (above) share a custom rig—complete with patchwork quilt and electric fireplace—they call their "Kozy Kabin."

# business dinner on the 52nd floor of Park Hyatt Tokyo: $359

(thinking "I love my job": priceless)

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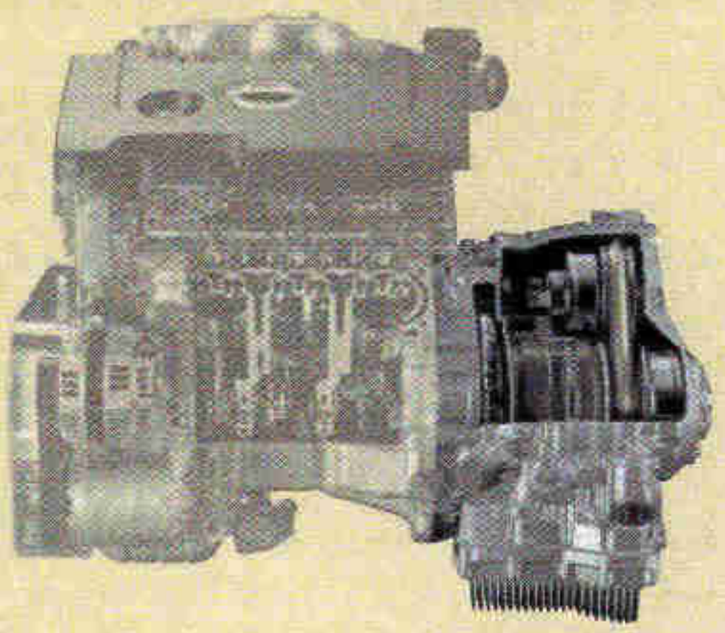
# PHOTO JOURNAL | KIM REIERSON



The cowboy hat, the pinup-girl T-shirt—how could I *not* take Troy Sharp's picture? He's an American icon: trucker as modern-day cowboy. When I met him at an Ontario, California, truck stop, Troy, in his mid-30s, had already been driving for 17 years. My driving career almost came to a crashing halt the day I was racing to catch a picture of Elvis on the back of a Florida moving van (left), until I finally got my chance at a timely tollbooth.



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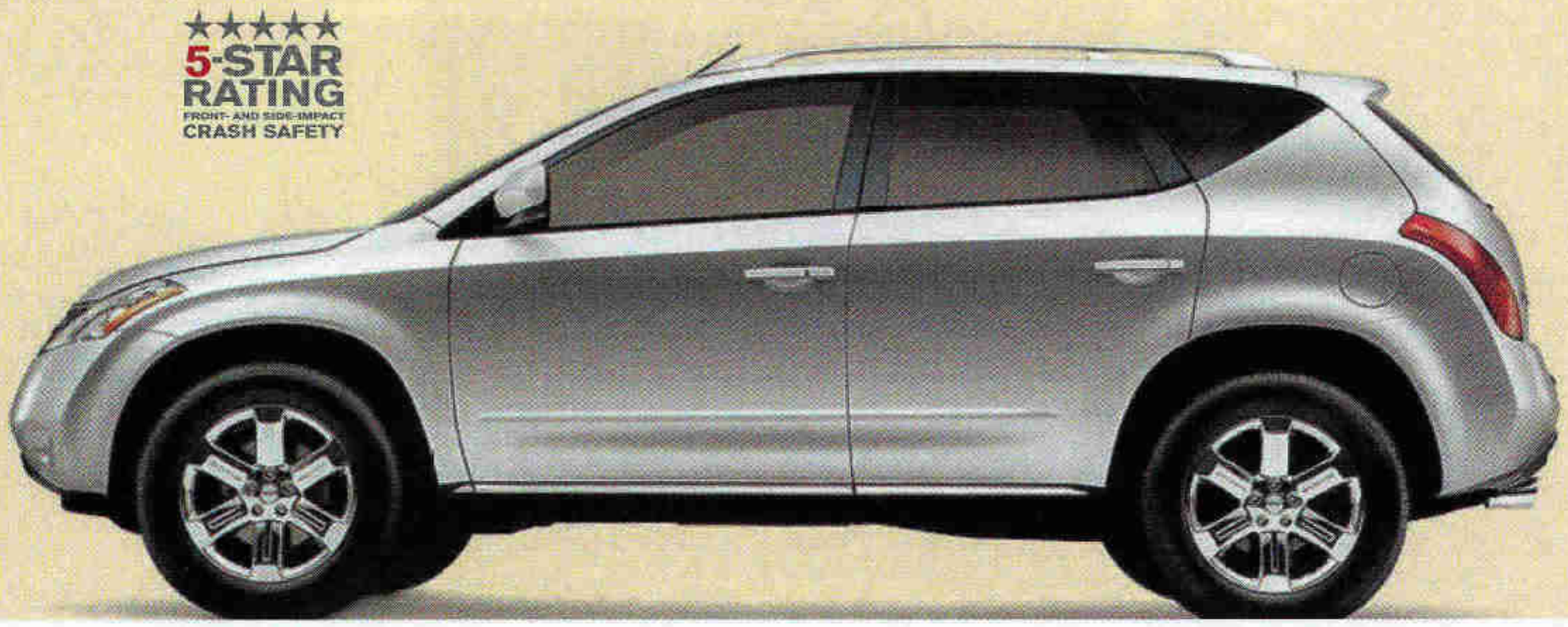

**The Nissan Murano**

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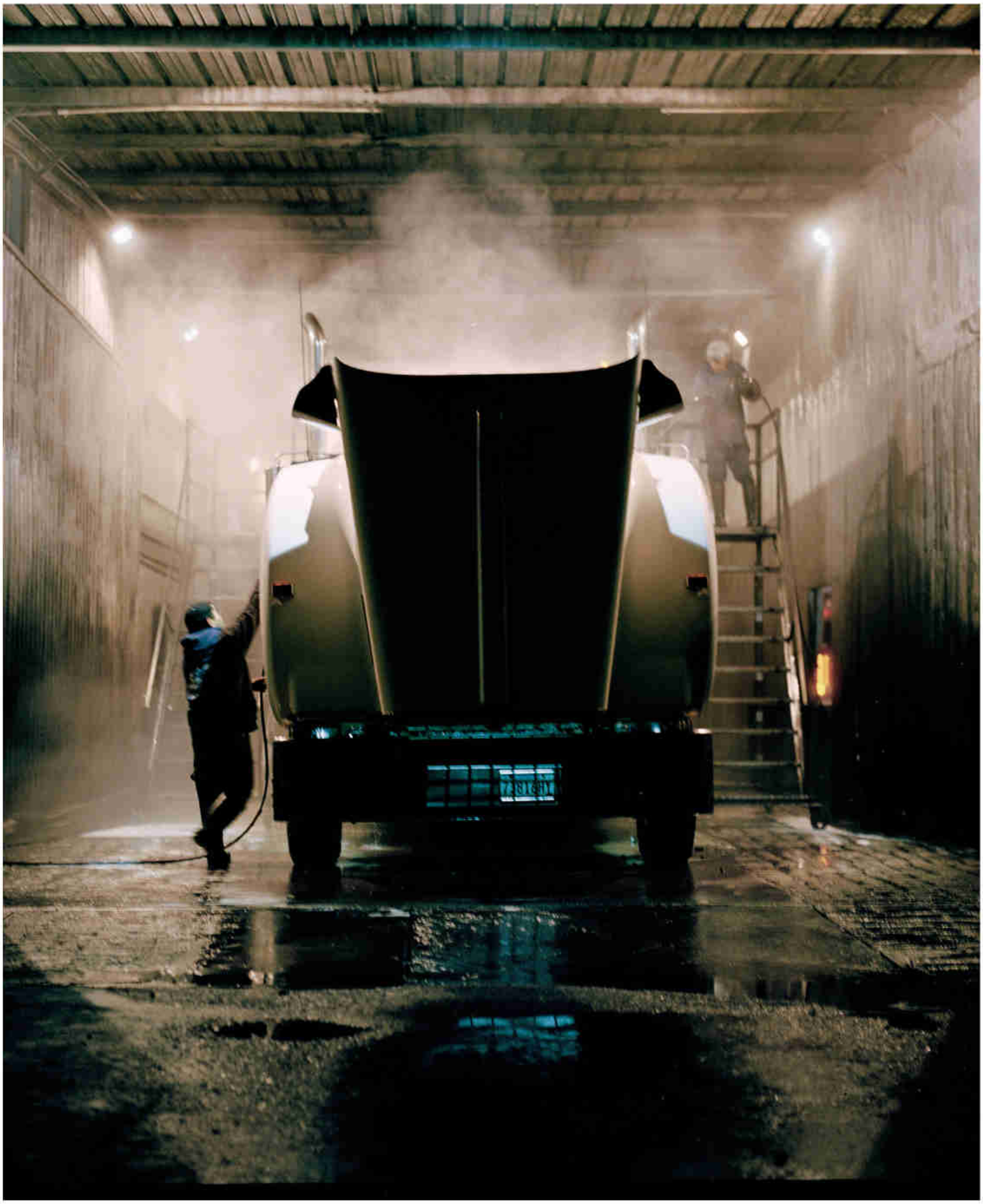
*2007 EPA fuel-economy estimates for Murano 2WD w/CVT are 20 mpg city/25 mpg highway. Actual mileage may vary. Government star ratings are part of the National Highway Traffic Safety Administration's (NHTSA's) New Car Assessment Program (www.safercar.gov). A 5-star rating is the highest government safety rating for driver and right-front-passenger seating positions in frontal crash tests and for front- and rear-passenger seating positions in side-impact crash tests. Model tested was 2007 Murano with standard side-impact air bags. Nissan, the Nissan Brand Symbol, "SHIFT_" tagline and Nissan model names are Nissan trademarks. Tread Lightly!® Please. Always wear your seat belt, and please don't drink and drive. 

# PHOTO JOURNAL | KIM REIERSON



I spotted the Truck Tub truck wash one night as I was driving down the freeway in Kingman, Arizona. I had to turn around to go back and get a shot of this scene: The enormity of the truck next to the two men reminded me of a big metal sculpture, and the dramatic way it was lit emphasized the "museum piece" quality.


## People with COPD breathe better with SPIRIVA.

If you have a history of smoking and breathing problems, it could be COPD (chronic obstructive pulmonary disease). COPD includes chronic bronchitis and emphysema.

*Ask your doctor about SPIRIVA, because it:*

- Is the only once-daily, inhaled maintenance prescription treatment for COPD
- Helps you breathe better for a full 24 hours by keeping airways open
- Is not a steroid

Please see brief summary of full Prescribing Information on reverse.

SPIRIVA does not replace fast-acting inhalers for sudden symptoms. Do not swallow the SPIRIVA capsule. The most common side effect of SPIRIVA is dry mouth. Others include constipation and problems passing urine. Tell your doctor about your medicines, including eye drops, and illnesses like glaucoma and urinary or prostate problems. These may worsen with SPIRIVA. If you have vision changes, eye pain, your breathing suddenly worsens, you get hives, or your throat or tongue swells, stop taking SPIRIVA and contact your doctor. For more information, call 1.877.SPIRIVA or visit spiriva.com

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SPIRIVA® HandiHaler®
(tiotropium bromide inhalation powder)

# SPIRIVA® HandiHaler®
## (tiotropium bromide inhalation powder)

## Spiriva® HandiHaler®(tiotropium bromide inhalation powder)

**FOR ORAL INHALATION ONLY**

**Brief Summary of Prescribing Information**

**INDICATIONS AND USAGE**

SPIRIVA HandiHaler (tiotropium bromide inhalation powder) is indicated for the long-term, once-daily, maintenance treatment of bronchospasm associated with chronic obstructive pulmonary disease (COPD), including chronic bronchitis and emphysema.

**CONTRAINDICATIONS**

SPIRIVA HandiHaler (tiotropium bromide inhalation powder) is contraindicated in patients with a history of hypersensitivity to atropine or its derivatives, including ipratropium, or to any component of this product.

**WARNINGS**

SPIRIVA HandiHaler (tiotropium bromide inhalation powder) is intended as a once-daily maintenance treatment for COPD and is not indicated for the initial treatment of acute episodes of bronchospasm, i.e., rescue therapy. Immediate hypersensitivity reactions, including angioedema, may occur after administration of SPIRIVA. If such a reaction occurs, therapy with SPIRIVA should be stopped at once and alternative treatments should be considered. Inhaled medicines, including SPIRIVA, may cause paradoxical bronchospasm. If this occurs, treatment with SPIRIVA should be stopped and other treatments considered.

**PRECAUTIONS**

**General**

As an anticholinergic drug, SPIRIVA (tiotropium bromide inhalation powder) may potentially worsen symptoms and signs associated with narrow-angle glaucoma, prostatic hyperplasia or bladder-neck obstruction and should be used with caution in patients with any of these conditions. As a predominantly renally excreted drug, patients with moderate to severe renal impairment (creatinin clearance of ≤50 mL/min) treated with SPIRIVA should be monitored closely (see **CLINICAL PHARMACOLOGY, Pharmacokinetics, Special Populations**, *Renally-impaired Patients*).

**Information for Patients**

It is important for patients to understand how to correctly administer SPIRIVA capsules using the HandiHaler inhalation device (**see Patient's Instructions for Use**). SPIRIVA capsules should only be administered via the HandiHaler device and the HandiHaler device should not be used for administering other medications. Capsules should always be stored in sealed blisters. Remove only one capsule immediately before use, or its effectiveness may be reduced. Additional capsules that are exposed to air (i.e., not intended for immediate use) should be discarded. Eye pain or discomfort, blurred vision, visual halos or colored images in association with red eyes from conjunctival congestion and corneal edema may be signs of acute narrow-angle glaucoma. Should any of these signs and symptoms develop, consult a physician immediately. Miotic eye drops alone are not considered to be effective treatment. Care must be taken not to allow the powder to enter into the eyes as this may cause blurring of vision and pupil dilation.

SPIRIVA HandiHaler is a once-daily maintenance bronchodilator and should not be used for immediate relief of breathing problems, i.e., as a rescue medication.

**Drug Interactions**

SPIRIVA has been used concomitantly with other drugs commonly used in COPD without increases in adverse drug reactions. These include sympathomimetic bronchodilators, methylxanthines, and oral and inhaled steroids. However, the co-administration of SPIRIVA with other anticholinergic-containing drugs (e.g., ipratropium) has not been studied and is therefore not recommended.

**Drug/Laboratory Test Interactions**

None known.

**Carcinogenesis, Mutagenesis, Impairment of Fertility**

No evidence of tumorigenicity was observed in a 104-week inhalation study in rats at tiotropium doses up to 0.059 mg/kg/day, in an 83-week inhalation study in female mice at doses up to 0.145 mg/kg/day, and in a 101-week inhalation study in male mice at doses up to 0.002 mg/kg/day. These doses correspond to 25, 35, and 0.5 times the Recommended Human Daily Dose (RHDD) on a $mg/m^2$ basis, respectively. These dose multiples may be over-estimated due to difficulties in measuring deposited doses in animal inhalation studies. Tiotropium bromide demonstrated no evidence of mutagenicity or clastogenicity in the following assays: the bacterial gene mutation assay, the V79 Chinese hamster cell mutagenesis assay, the chromosomal aberration assays in human lymphocytes *in vitro* and mouse micronucleus formation *in vivo*, and the unscheduled DNA synthesis in primary rat hepatocytes *in vitro* assay. In rats, decreases in the number of corpora lutea and the percentage of implants were noted at inhalation tiotropium doses of 0.078 mg/kg/day or greater (approximately 35 times the RHDD on a $mg/m^2$ basis). No such effects were observed at 0.009 mg/kg/day (approximately 4 times than the RHDD on a $mg/m^2$ basis). The fertility index, however, was not affected at inhalation doses up to 1.689 mg/kg/day (approximately 760 times the RHDD on a $mg/m^2$ basis). These dose multiples may be over-estimated due to difficulties in measuring deposited doses in animal inhalation studies.

**Pregnancy**

**Pregnancy Category C**

No evidence of structural alterations was observed in rats and rabbits at inhalation tiotropium doses of up to 1.471 and 0.007 mg/kg/day, respectively. These doses correspond to approximately 660 and 6 times the recommended human daily dose (RHDD) on a $mg/m^2$ basis. However, in rats, fetal resorption, litter loss, decreases in the number of live pups at birth and the mean pup weights, and a delay in pup sexual maturation were observed at inhalation tiotropium doses of ≥0.078 mg/kg (approximately 35 times the RHDD on a $mg/m^2$ basis). In rabbits, an increase in post-implantation loss was observed at an inhalation dose of 0.4 mg/kg/day (approximately 360 times the RHDD on a $mg/m^2$ basis). Such effects were not observed at inhalation doses of 0.009 and up to 0.088 mg/kg/day in rats and rabbits, respectively. These doses correspond to approximately 4 and 80 times the RHDD on a $mg/m^2$ basis, respectively. These dose multiples may be over-estimated due to difficulties in measuring deposited doses in animal inhalation studies. There are no adequate and well-controlled studies in pregnant women. SPIRIVA should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

**Use in Labor and Delivery**

The safety and effectiveness of SPIRIVA has not been studied during labor and delivery.

**Nursing Mothers**

Clinical data from nursing women exposed to tiotropium are not available. Based on lactating rodent studies, tiotropium is excreted into breast milk. It is not known whether tiotropium is excreted in human milk, but because many drugs are excreted in human milk and given these findings in rats, caution should be exercised if SPIRIVA is administered to a nursing woman.

**Pediatric Use**

SPIRIVA HandiHaler is approved for use in the maintenance treatment of bronchospasm associated with chronic obstructive pulmonary disease, including chronic bronchitis and emphysema. This disease does not normally occur in children. The safety and effectiveness of SPIRIVA in pediatric patients have not been established.

**Geriatric Use**

Of the total number of patients who received SPIRIVA in the 1-year clinical trials, 426 were <65 years, 375 were 65–74 years and 105 were ≥75 years of age. Within each age subgroup, there were no differences between the proportion of patients with adverse events in the SPIRIVA and the comparator groups for most events. Dry mouth increased with age in the SPIRIVA group (differences from placebo were 9.0%, 17.1%, and 16.2% in the aforementioned age subgroups). A higher frequency of constipation and urinary tract infections with increasing age was observed in the SPIRIVA group in the placebo-controlled studies. The differences from placebo for constipation were 0%, 1.8%, and 7.8% for each of the age groups. The differences from placebo for urinary tract infections were −0.6%, 4.6% and 4.5%. No overall differences in effectiveness were observed among these groups. Based on available data, no adjustment of SPIRIVA dosage in geriatric patients is warranted.

**ADVERSE REACTIONS**

Of the 2,663 patients in the four 1-year and two 6-month controlled clinical trials, 1,308 were treated with SPIRIVA (tiotropium bromide inhalation powder) at the recommended dose of 18 mcg once a day. Patients with narrow angle glaucoma, or symptomatic prostatic hypertrophy or bladder outlet obstruction were excluded from these trials. The most commonly reported adverse drug reaction was dry mouth. Dry mouth was usually mild and often resolved during continued treatment. Other reactions reported in individual patients and consistent with possible anticholinergic effects included constipation, increased heart rate, blurred vision, glaucoma, urinary difficulty, and urinary retention. Four multicenter, 1-year, controlled studies evaluated SPIRIVA in patients with COPD. Table 1 shows all adverse events that occurred with a frequency of ≥3% in the SPIRIVA group in the 1-year placebo-controlled trials where the rates in the SPIRIVA group exceeded placebo by ≥1%. The frequency of corresponding events in the ipratropium-controlled trials is included for comparison.

**Table 1: Adverse Experience Incidence (% Patients) in One-Year-COPD Clinical Trials**

| Body System (Event) | Placebo-Controlled Trials | | Ipratropium-Controlled Trials | |
|---|---|---|---|---|
| | SPIRIVA [n = 550] | Placebo [n = 371] | SPIRIVA [n = 356] | Ipratropium [n = 179] |
| **Body as a Whole** | | | | |
| Accidents | 13 | 11 | 5 | 8 |
| Chest Pain (non-specific) | 7 | 5 | 5 | 2 |
| Edema, Dependent | 5 | 4 | 3 | 5 |
| **Gastrointestinal System Disorders** | | | | |
| Abdominal Pain | 5 | 3 | 6 | 6 |
| Constipation | 4 | 2 | 1 | 1 |
| Dry Mouth | 16 | 3 | 12 | 6 |
| Dyspepsia | 6 | 5 | 1 | 1 |
| Vomiting | 4 | 2 | 1 | 2 |
| **Musculoskeletal System** | | | | |
| Myalgia | 4 | 3 | 4 | 3 |
| **Resistance Mechanism Disorders** | | | | |
| Infection | 4 | 3 | 1 | 3 |
| Moniliasis | 4 | 2 | 3 | 2 |
| **Respiratory System (upper)** | | | | |
| Epistaxis | 4 | 2 | 1 | 1 |
| Pharyngitis | 9 | 7 | 7 | 3 |
| Rhinitis | 6 | 5 | 3 | 2 |
| Sinusitis | 11 | 9 | 3 | 2 |
| Upper Respiratory Tract Infection | 41 | 37 | 43 | 35 |
| **Skin and Appendage Disorders** | | | | |
| Rash | 4 | 2 | 2 | 2 |
| **Urinary System** | | | | |
| Urinary Tract Infection | 7 | 5 | 4 | 2 |

Arthritis, coughing, and influenza-like symptoms occurred at a rate of ≥3% in the SPIRIVA treatment group, but were <1% in excess of the placebo group. Other events that occurred in the SPIRIVA group at a frequency of 1–3% in the placebo-controlled trials where the rates exceeded that in the placebo group include: *Body as a Whole:* allergic reaction, leg pain; *Central and Peripheral Nervous System:* dysphonia, paresthesia; *Gastrointestinal System Disorders:* gastrointestinal disorder not otherwise specified (NOS), gastroesophageal reflux, stomatitis (including ulcerative stomatitis); *Metabolic and Nutritional Disorders:* hypercholesterolemia, hyperglycemia; *Musculoskeletal System Disorders:* skeletal pain; *Cardiac Events:* angina pectoris (including aggravated angina pectoris); *Psychiatric Disorder:* depression; *Infections:* herpes zoster; *Respiratory System Disorder (Upper):* laryngitis; *Vision Disorder:* cataract In addition, among the adverse events observed in the clinical trials with an incidence of <1% were atrial fibrillation, supraventricular tachycardia, angioedema, and urinary retention. In the 1-year trials, the incidence of dry mouth, constipation, and urinary tract infection increased with age (see **PRECAUTIONS, Geriatric Use**). Two multicenter, 6-month, controlled studies evaluated SPIRIVA in patients with COPD. The adverse events and the incidence rates were similar to those seen in the 1-year controlled trials. The following adverse reactions have been identified during worldwide post-approval use of SPIRIVA: dizziness, dysphagia, epistaxis, hoarseness, intestinal obstruction including ileus paralytic, intraocular pressure increased, oral candidiasis, palpitations, pruritus, tachycardia, throat irritation, and urticaria.

**DOSAGE AND ADMINISTRATION**

The recommended dosage of SPIRIVA HandiHaler (tiotropium bromide inhalation powder) is the inhalation of the contents of one SPIRIVA capsule, once-daily, with the HandiHaler inhalation device (see **Patient's Instructions for Use**). No dosage adjustment is required for geriatric, hepatically-impaired, or renally-impaired patients. However, patients with moderate to severe renal impairment given SPIRIVA should be monitored closely (see **CLINICAL PHARMACOLOGY, Pharmacokinetics, Special Populations** and **PRECAUTIONS**). SPIRIVA capsules are for inhalation only and must not be swallowed.

**HOW SUPPLIED**

The following packages are available:
carton containing 5 SPIRIVA capsules (1 unit-dose blister card) and 1 HandiHaler inhalation device (NDC 0597-0075-75)
carton containing 30 SPIRIVA capsules (3 unit-dose blister cards) and 1 HandiHaler inhalation device (NDC 0597 0075-41)
carton containing 90 SPIRIVA capsules (9 unit-dose blister cards) and 1 HandiHaler inhalation device (NDC 0597 0075-47)

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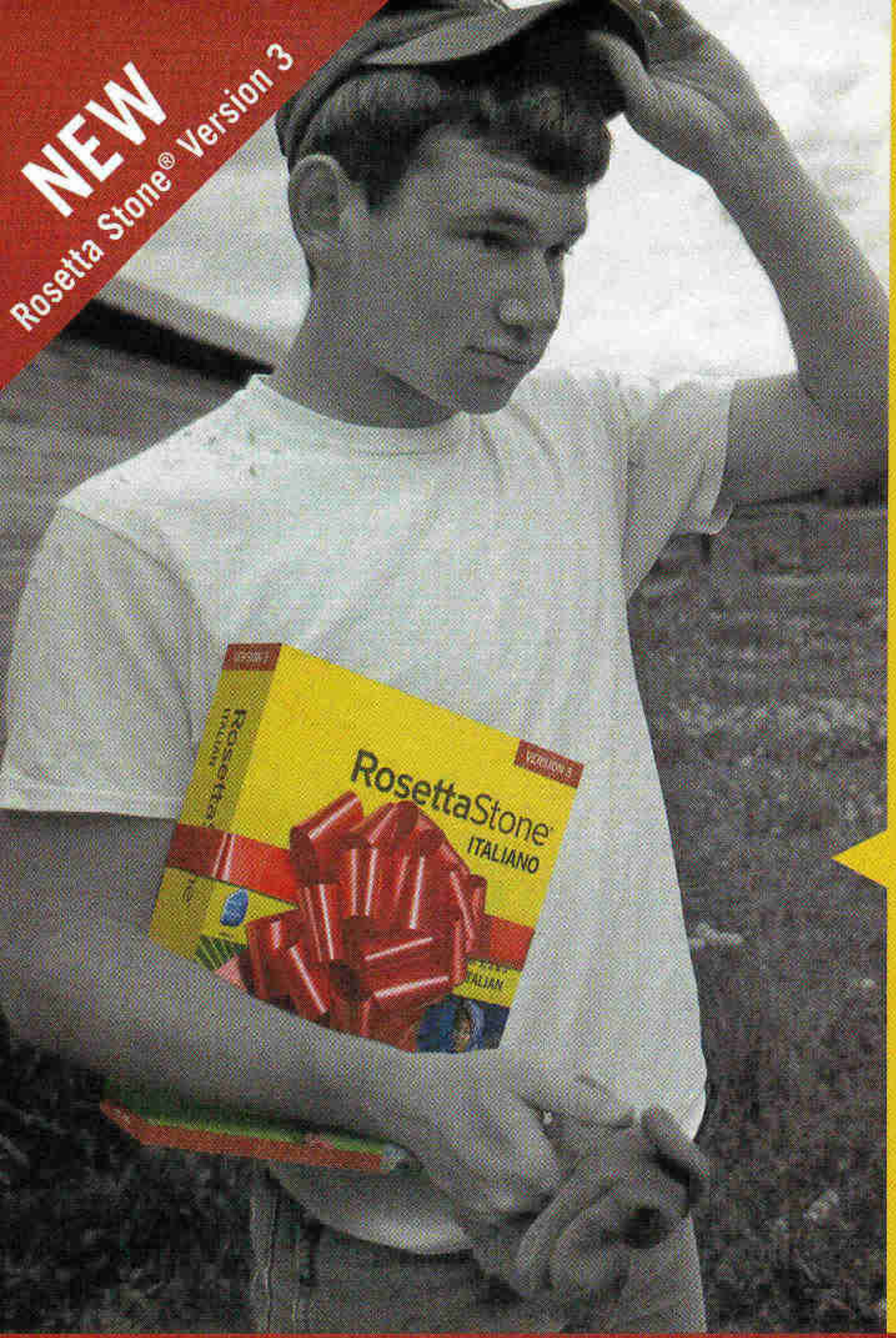


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# VISIONS OF EARTH

**New York City** Splashing up Fifth Avenue in homage to the majestic lakes of Italy's Varese Province, swimmer Irina Losnjykoua was among 35,000 celebrants of all things Italian-American in the city's 2006 Columbus Day parade.

PHOTO: MICHAEL CHRISTOPHER BROWN, GETTY IMAGES

**Netherlands** To honor 25 years of Terschelling island's Oerol theater festival, 2,000 people lined up along 25 giant rings of sand sculpted on the beach, in what artist Rob Sweere called "a silent conversation with the sky."

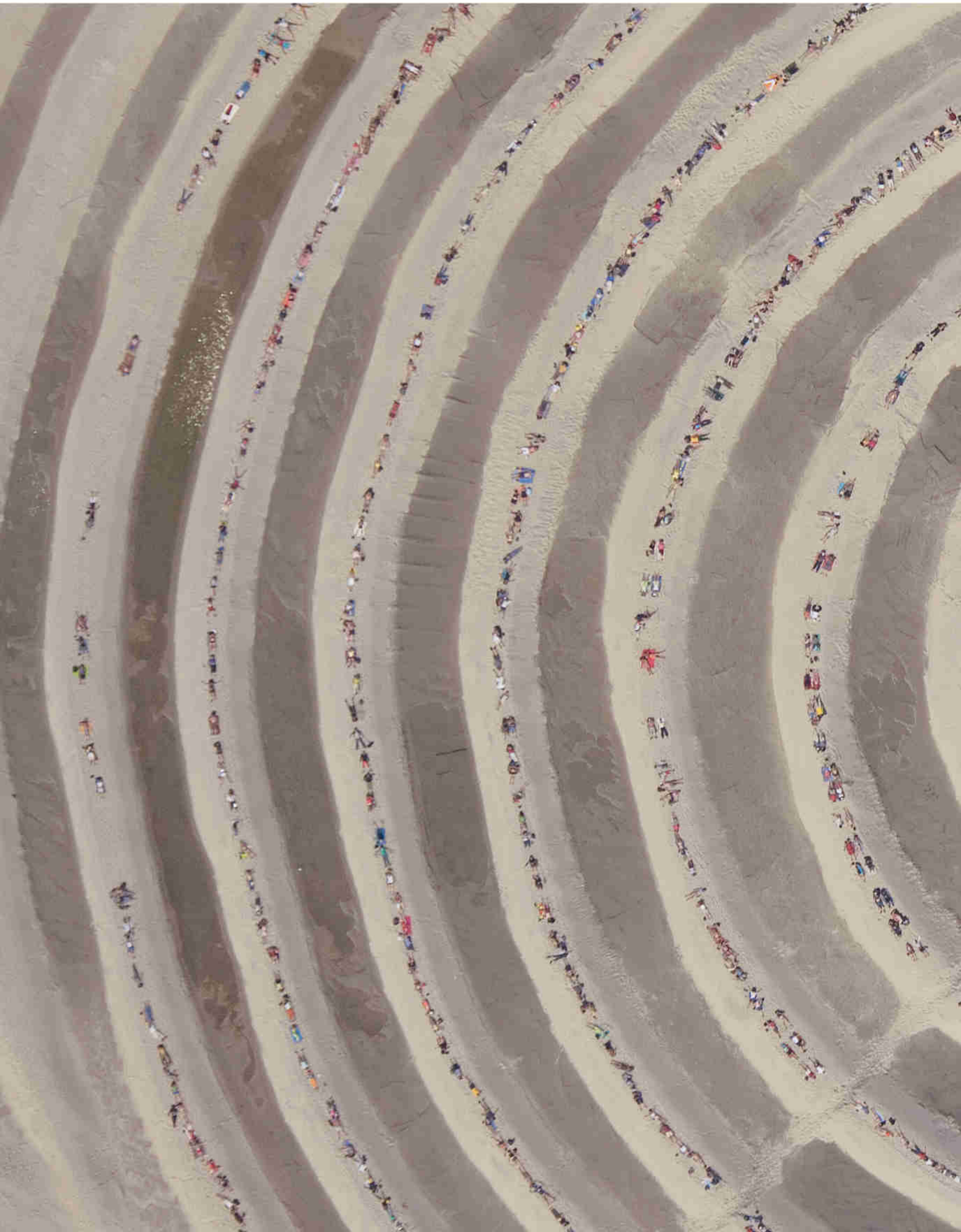
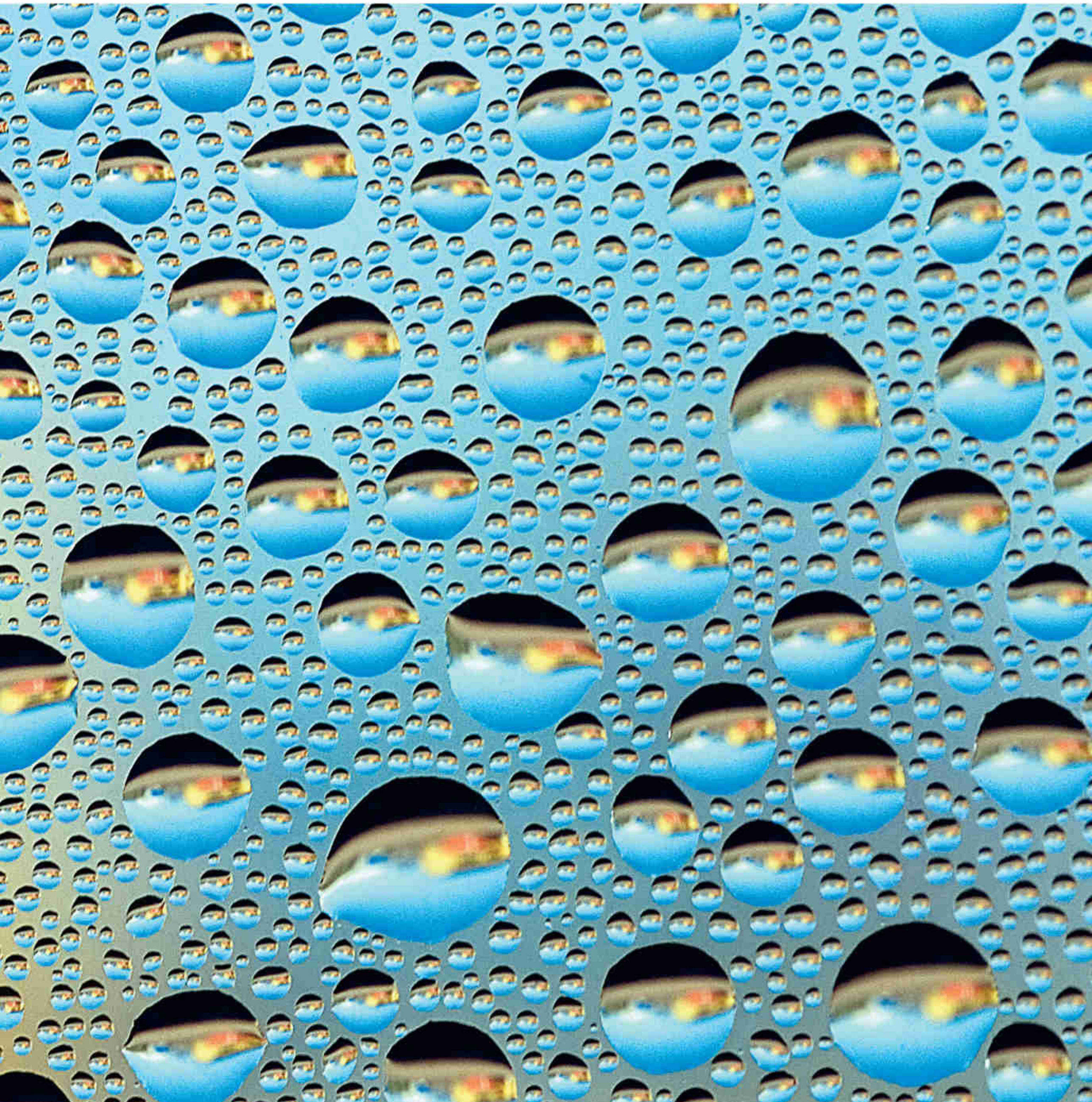


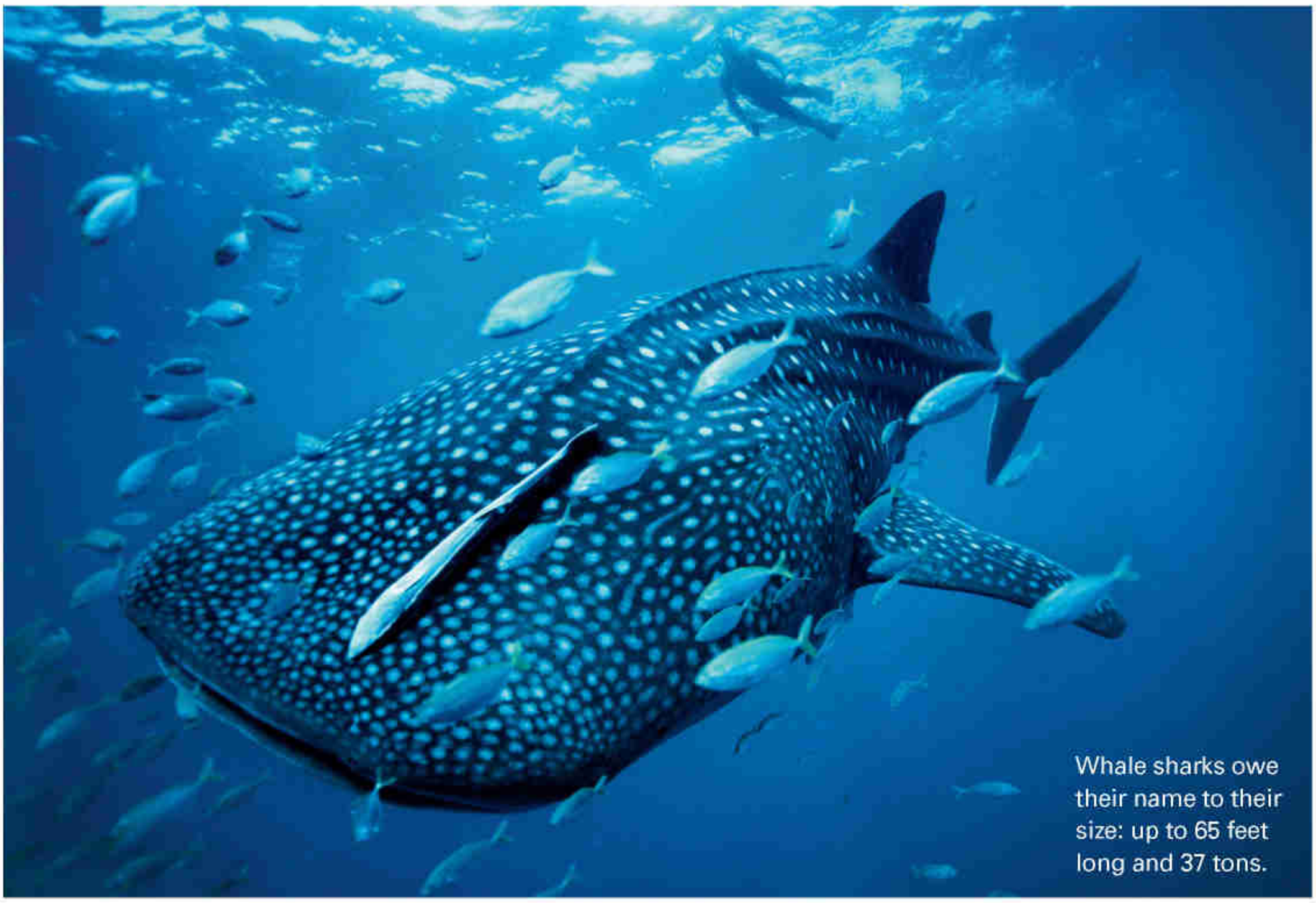
PHOTO: MARC VREULS, ANP/SIPA PRESS

**Finland** On a window in Kotka, a slightly battered mosquito sits silhouetted against a mosaic of water drops, each reflecting spring sky and the crayon colors of nearby buildings.

**See More** Visions of Earth images at **visionsofearth.ngm.com.**

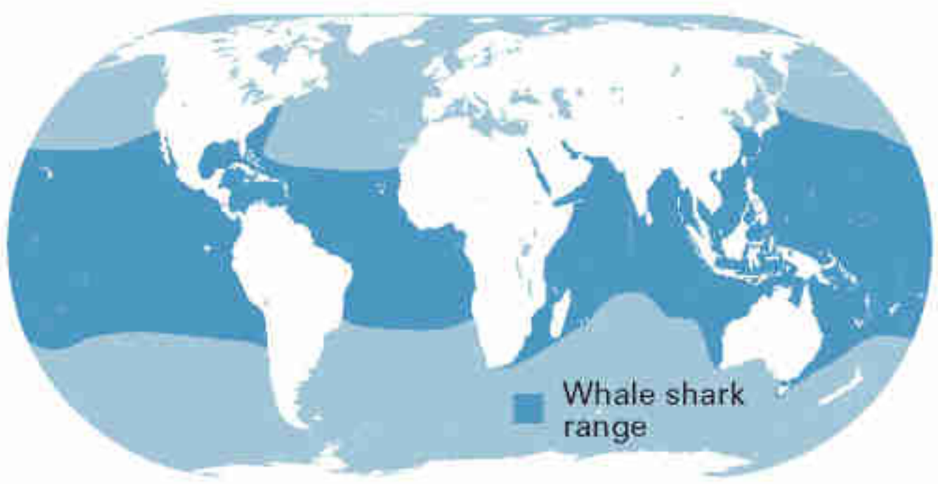
PHOTO: JUHANI KOSONEN





Whale sharks owe their name to their size: up to 65 feet long and 37 tons.

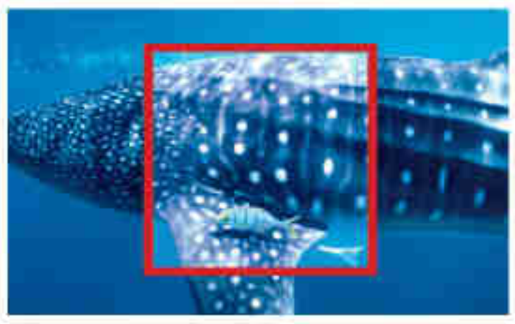
**Whale Shark Paparazzi** Huge, docile whale sharks live in oceans around the world, but no one knows where they breed, their migration routes, or even how many there are. Researchers hope to fill in the blanks by cataloging photographs taken by both experts and amateurs. One database, the Ecocean Whale Shark Photo-identification Library, has so far collected thousands of images, displayed at *whaleshark.org,* and identified some 830 sharks by the landscape of white blobs on the skin just behind the gills. To match pictures of the starlike patterns, scientists borrowed a method that astronomers use to line up pictures of stars. They can tell when a shark in the library is photographed again, which lets them track a particular fish over time and in different locations. Project directors Brad Norman and Jason Holmberg hope to learn whether recent bans on fishing the shark will bolster its population. Ecocean is training ecotourism operators and others to get involved in photographing—and conserving—the world's largest fish. —*Helen Fields*




**SUBMIT YOUR SHARK**

Ecocean adds your photos of whale sharks to its library and tells you if there's a match.

- **Rules** They don't bite, but that tail packs a wallop, so stay at least ten feet away—and don't touch!
- **Position** Take the photo from the shark's left, perpendicular to the patterned area above the left pectoral fin (below).
- **Bonus** Documenting scars on the head, fins, and body can help identify sharks seen before.



PHOTOS: BRIAN SKERRY (TOP); BRAD NORMAN, ECOCEAN INC. NGM MAPS

The **Ameriprise Financial**

# LifeDreams

#2 IN A SERIES

## Healing Horses

**Having a plan, and the courage to pursue it,** helped one small-business owner realize her life's dream of establishing a sanctuary for injured performance horses—a journey that proved to be more rewarding than she could ever imagine.

## Believing in a **Dream**

From the time she was a small child, Alexis Ells remembers rescuing injured animals and bringing them home for care. By continuing to listen to her innate passion for healing, Ells created her life's work, and today is the founding director of The Equine Sanctuary, a nonprofit organization that rescues, rehabilitates, and retrains injured performance horses that can no longer professionally compete. Located in Ojai, California, the sanctuary accommodates horses that usually require extensive veterinary care and are at high risk of being euthanized. Through her work, she, along with the help of a team of dedicated volunteers, has improved—and often saved—the lives of hundreds of horses. Most horses are rehabilitated, then adopted by families, leading to long productive lives. Those that require ongoing care remain as goodwill ambassadors in the sanctuary's educational and therapeutic programs for children and adults.

Although she is greatly admired for her work, the world wasn't quite ready for Ells's vision two decades ago. "When I first moved from New York to California and said I do structural integration, acupuncture, homeopathy, and nutrition for animals, people just looked at me and said, 'What planet did you drop in from? You will never be a success. No one is going to ever be interested in that,'" says Ells. Today her clients come from all over the world.

Ells is able to fund The Equine Sanctuary through donations, grants, events, memberships, and in-kind contributions. All of the sanctuary's horses benefit from the products donated by Ells's business, TerraOceana.com, a company that formulates and manufactures whole food organic supplements and homeopathics for people, dogs, cats, and horses. Her career has unfolded through a seemingly natural process. "I was one of those blessed people who always knew what I wanted to do." Although her life's mission has been clear, the road hasn't always been easy. Ells had a car accident in 1988 and suffered a serious brain injury, losing many of her most basic abilities. Despite a grim prognosis, Ells proved her doctors wrong and, after four years of grueling rehabilitation, prevailed. And while the accident ended her competitive riding career, she is no longer in a wheelchair, can speak, read, write, run the sanctuary, run her company—and ride and train horses. Ells says the accident and its aftermath have given her tremendous freedom. Every day now is an opportunity to live with greater awareness and renewed purpose.

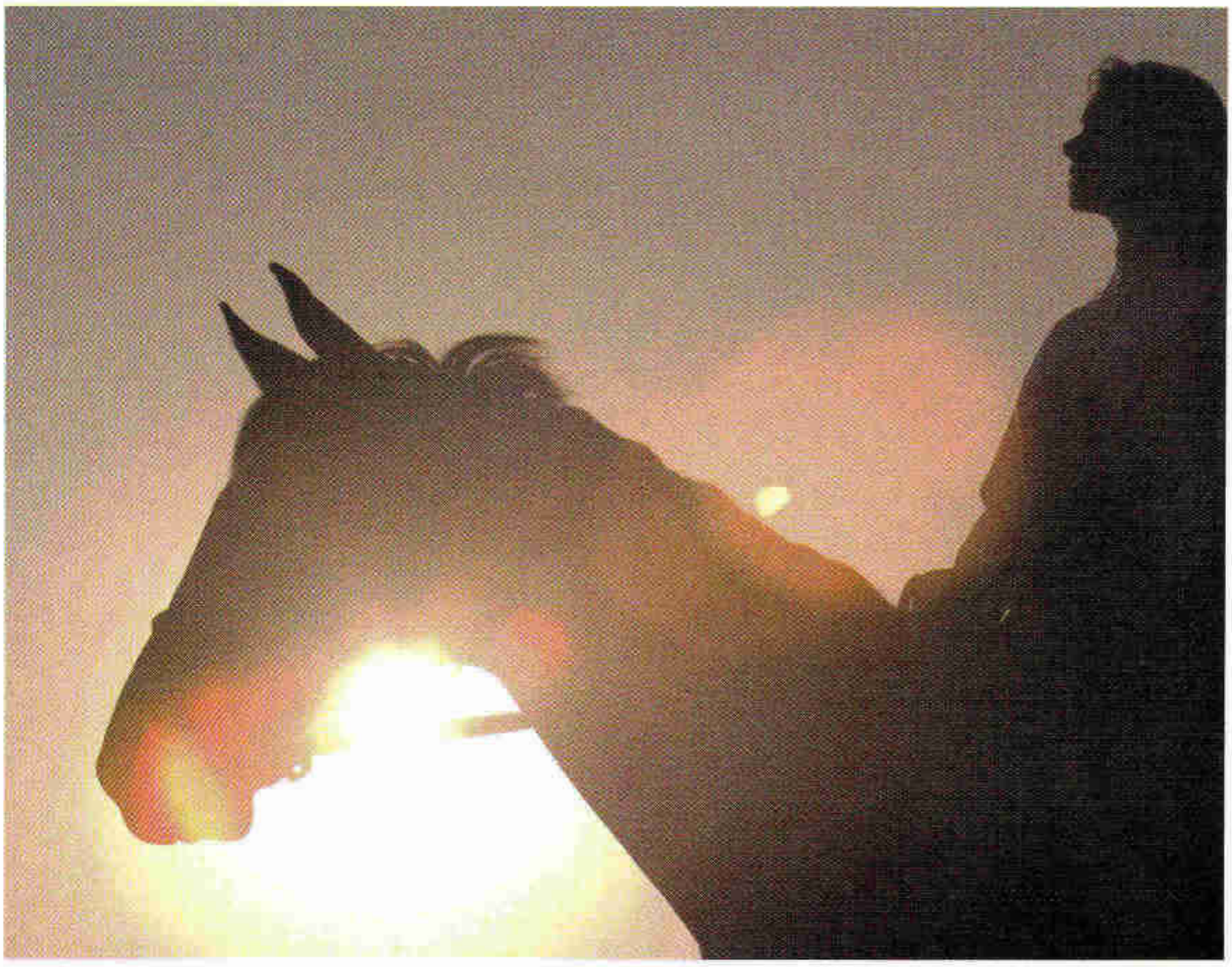
> "I've just said yes to my gift, yes to my passions, yes to creating a plan that would fulfill my life's dream."

## Passion for the **Plan**

Ells believes her success stems from her attitude that being challenged in life is inevitable…being defeated is optional. For inspiration she often thinks about the trials and tribulations of history's most successful figures. She looks to Thomas Edison who tried thousands of experiments before he invented the lightbulb. "Edison once said, 'When you exhaust all possibilities, remember this: you haven't.' I think it's about perception and perspective." She believes there are no mistakes, only opportunities for redirection. "If you give yourself the freedom to know that anything is possible, and you keep having faith, belief, and perseverance despite the odds, you will eventually arrive at the top of the mountain," she says.



*Photography made possible by National Geographic Image Collection; Dawn Kish, photographer.*



## On the Right **Track**

Bettering the lives of horses and people is what drives Ells day after day. "My life is fulfilling because I know that I impact, alter, and transform thousands of animals' and people's lives in the course of my journey here." So what is it about horses that fuels Ells's indomitable spirit? With great feeling, Ells offers this: "Horses are so magnificent, so bold, so courageous …and like humans, so fragile in many ways. They are the true emissaries of unconditional love. They have contributed so much to humanity, carried countries to war without judgment, helped us build civilizations, been a means of transportation, and have enabled us to hunt for food. Yet they also give humans the extraordinary ability to fly over the earth at 35 miles per hour with an exhilarating sense of freedom."

As a woman who does her best to live in the present moment, Ells believes in working toward a goal. "It's important to set a course and to measure one's progress." Ells and her volunteers actively work to raise funds for the sanctuary. "We are determined to expand our educational and therapeutic programs and improve our facility so we can help more horses." In a final thought, Ells, ever the optimist, reveals her compassion and connection to these horses. Her ongoing commitment is to teach our youth that although hardships may befall us, we can choose to turn our tragedies into triumphs. That all sentient creatures have value…and that life is not disposable. Ells quotes Tom Smith, Seabiscuit's trainer, who once said, "You don't throw away a whole life just because it's a little banged up."

**Go online to follow Alexis Ells's story** and see these beautiful horses at ***nationalgeographic.com/LifeDreams***

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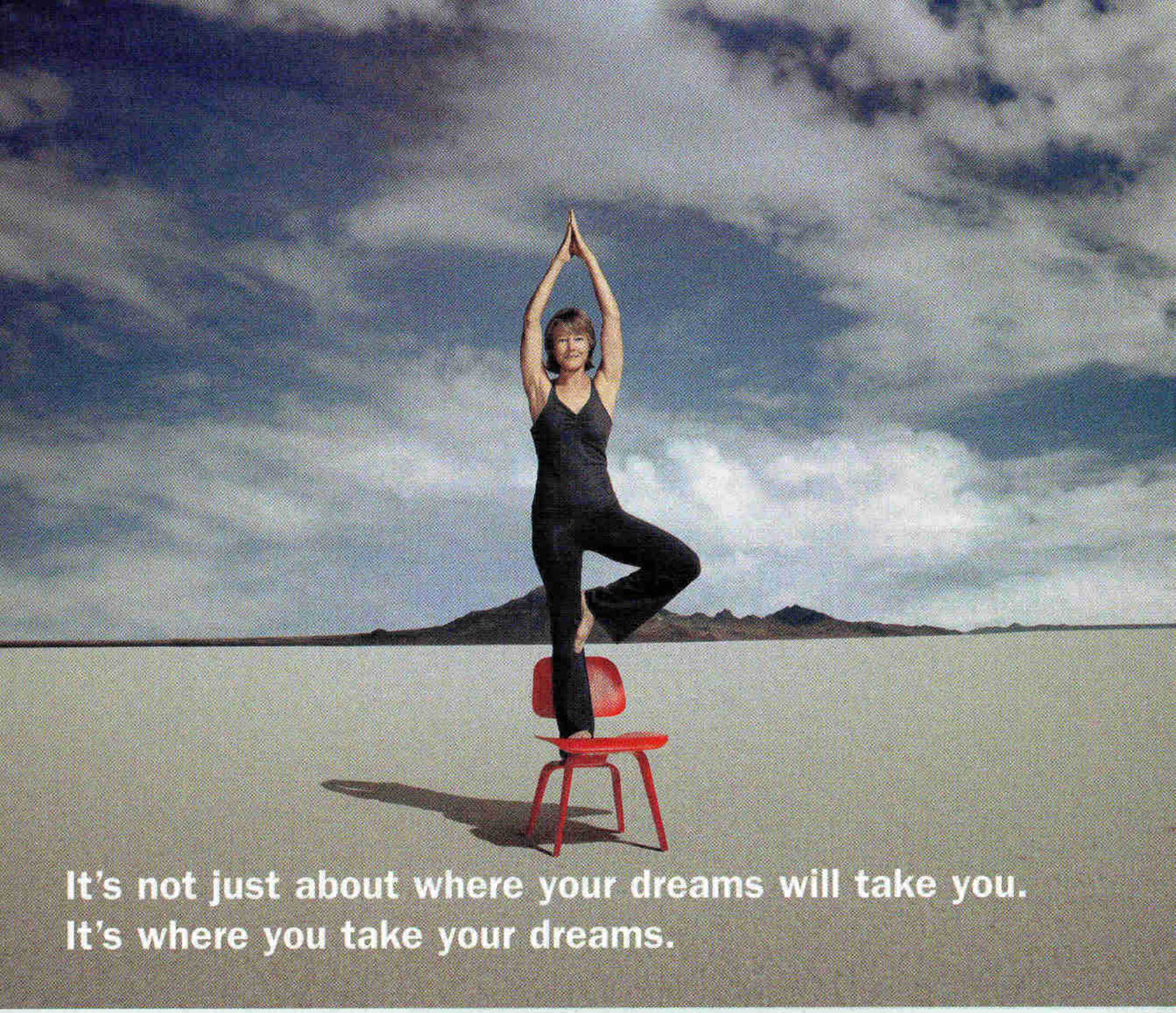

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Giant turkey drumsticks are a trendy snack at theme parks.

## Global Gobblers

When it comes to turkey consumed per person, Israel leads the world: just over 34 pounds a year. "And we don't even have Thanksgiving!" says a consulate spokeswoman. Israel brought the birds over from the U.S. in the 1950s. In a country where red meat is expensive and pork is not kosher, turkeys provide a lot of meat that can be served a lot of ways. Jerusalem food writer Barbara Sofer has seen turkey schnitzel and kebabs and even turkey carved up to look like lamb chops. An avian flu outbreak last year did not dissuade the turkey-eating public.

But the U.S. is no turkey slouch, raising 272 million gobblers a year. The bird is, after all, a native, domesticated from the feisty wild turkey that Ben Franklin thought should be the national bird. Nowadays, hens are often holiday dinner—they're harvested at about 15 pounds. Toms easily hit 40; they're the source of deli meats. True fact: Turkeys are now bred so big they must be artificially inseminated. Up for debate: turkey IQ. "About as smart as any bird," says Iowa State University veterinarian Darrell Trampel. Israeli poultry geneticist Gaddi Zeitlin states, "It's a very stupid animal." *—Marc Silver*

**TOP TURKEY EATERS**

*Pounds per capita, 2005*

| | | |
|---|---|---|
| 1 | Israel | **34.6** |
| 2 | Slovakia | **31.3** |
| 3 | United States | **16.1** |
| 4 | France | **13.7** |
| 5 | Hungary | **12.8** |
| 6 | Grenada | **12.1** |
| 7 | Dominica | **11.2** |
| 7 | Ireland | **11.2** |
| 7 | Samoa | **11.2** |

PHOTO: NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN. SOURCES: FOOD AND AGRICULTURE ORGANIZATION, UNITED NATIONS; CANADIAN TURKEY MARKETING AGENCY

Dictabelt #10 contains sounds from that tragic day in Dallas. But the belt is old, its surface is brittle, and its fate uncertain.

**Saving Sounds of History** Images of the day President John F. Kennedy was gunned down haven't faded away, but the original copy of an audio recording just might. Residing on a 3.5-inch-wide loop of plastic called a Dictabelt, the sounds were captured when a two-way police radio aboard a motorcycle escort got stuck in the "on" position. At Dallas police headquarters, a machine like the one pictured below recorded the transmissions. But after many replayings of the Dictabelt, its sound quality degraded. Now, scientists at Lawrence Berkeley National Laboratory are looking into ways to restore aging Dictabelts by optically scanning the analog grooves. Because of the fuzziness of the original Dallas recording, experts don't know if the Dictabelt would shed new light on the events of November 22, 1963, but the technique could give new life to thousands of dictation belts deteriorating at the National Archives. Among them: U.S. interrogations of suspected Nazi war criminals after World War II and voices of Eskimo elders recorded by explorer Svend Frederiksen from 1957 to 1965. *—Alan Mairson*

PHOTOS (CLOCKWISE FROM TOP): DONALD K. MURRAY; DICTAPHONE CORPORATION; CHARLIE MAYN, NATIONAL ARCHIVES

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| Compare For Yourself at 2 carats | | |
|---|---|---|
| | Mined Flawless Diamond | Diamond*Aura* Compares to: |
| Hardness | Cuts Glass | Cuts Glass |
| Cut (58 facets) | Brilliant | Brilliant |
| Color | "D" Colorless | "D" Colorless |
| Clarity | "IF" | "F" Faultless |
| Dispersion/Fire | 0.044 | 0.066 |
| 2 ct tw necklace | $20,000+ | $129 |

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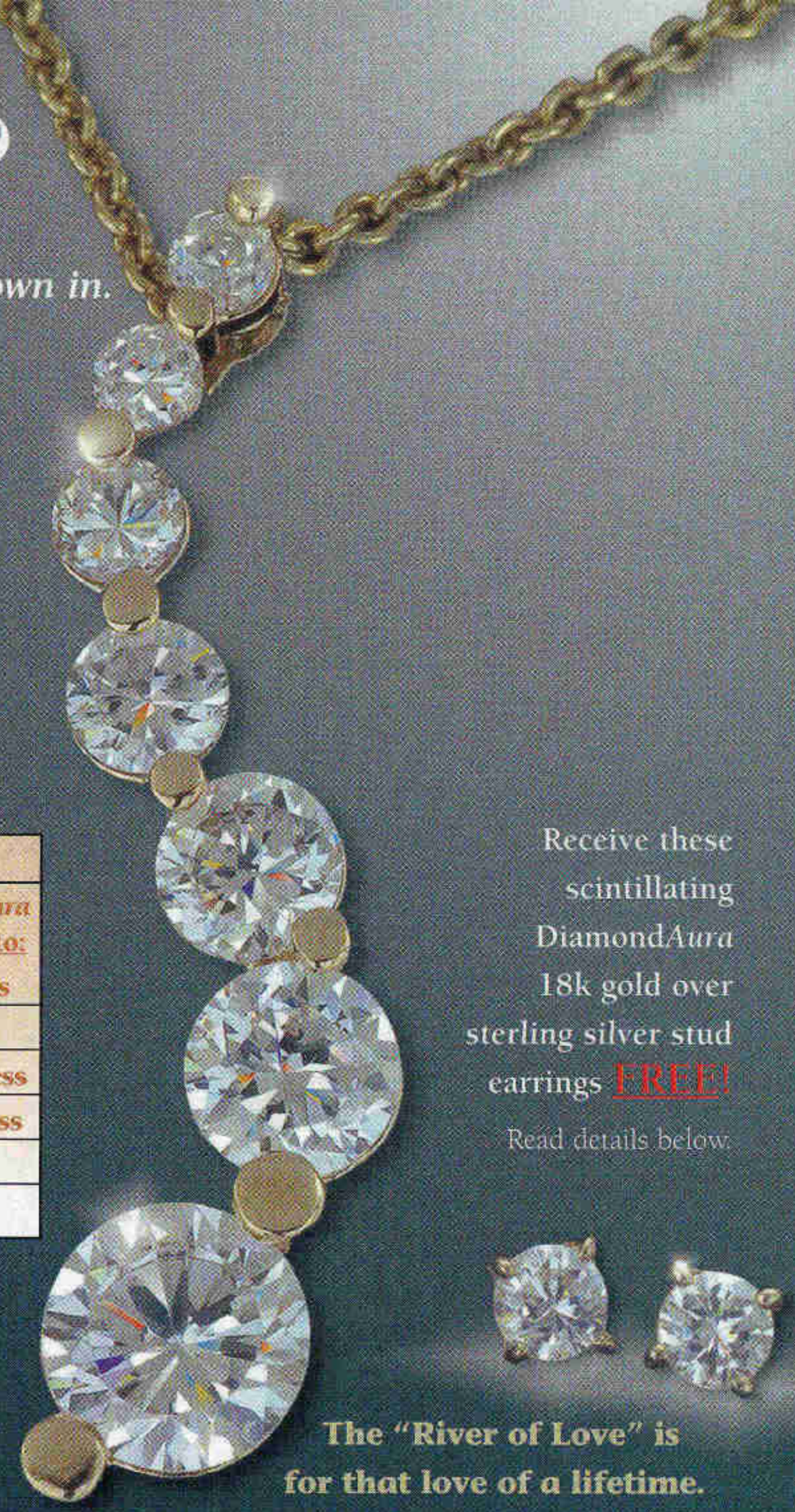

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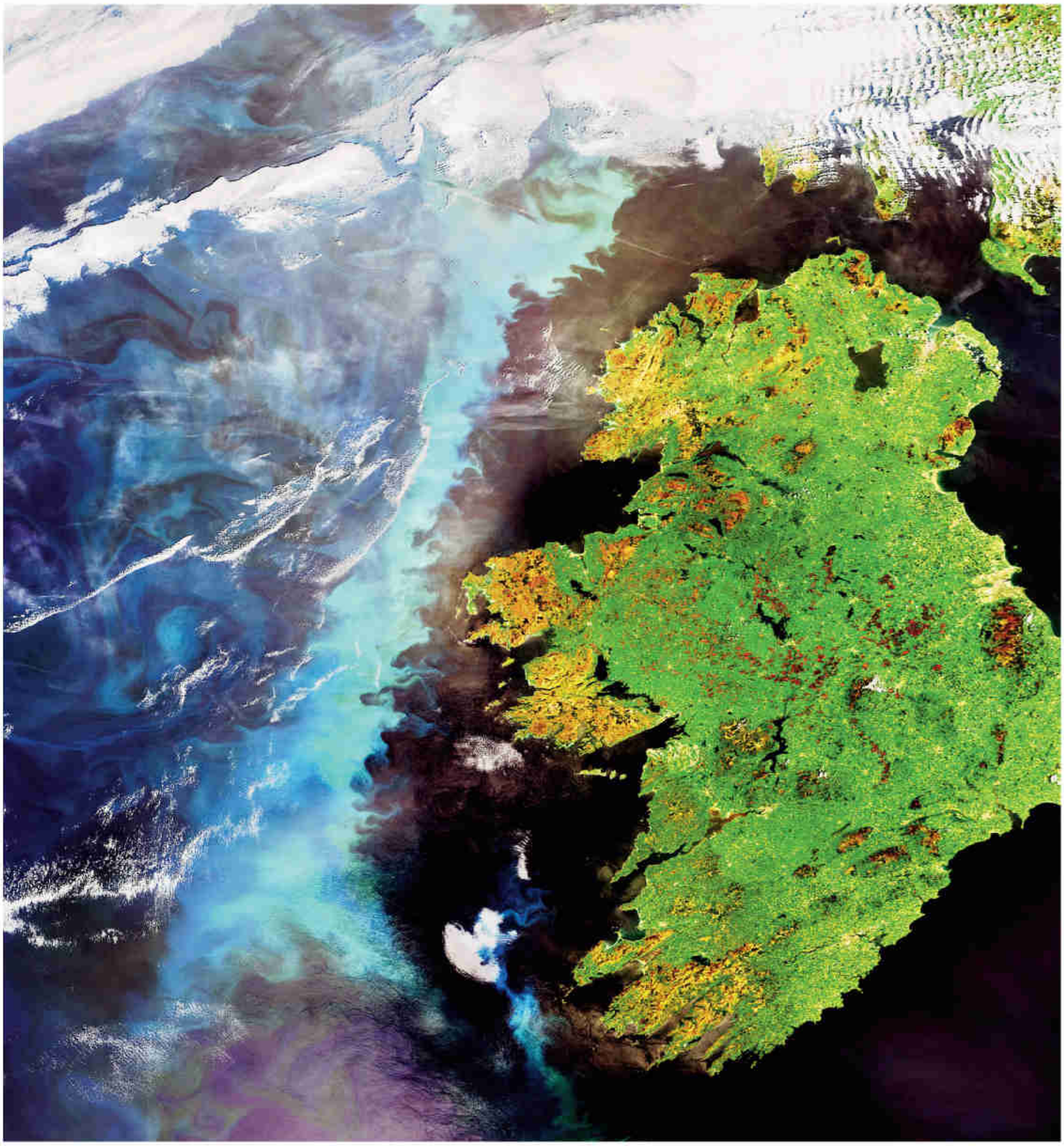
# WHERE IN THE WORLD?



A spectacular algae bloom, a short-lived spring event, stretches for about 300 miles off Ireland's coast.

**Blooming Fine Day** An emerald green pelt, a shape like a shaggy billy goat, and a moat of seawater give all the clues you need: It's Ireland, as eyed by a satellite, enjoying an island-wide sunny day in early June. A more puzzling feature is the flare of milky blue off the west coast. In spring, a confluence of light and a mixing of nutrients can spark the blooming of a huge pasture of phyto-plankton for a few weeks in the Atlantic. The algae on show, says Pauhla McGrane, a marine biologist with the National University of Ireland, Galway, are coccolithophores, single-celled organisms covered with calcium carbonate plates. The tropical color comes from sunlight scattered off trillions of plates, which detach as the cells die, a flashy send-off after a burst of life. *—Tom O'Neill*

PHOTO: ESA

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# Most Polluted Places

Filthy air, foul water, and sullied soil mark an environmental group's Dirty Thirty.


Sulfur and arsenic spew from coal refineries in Linfen, China, poisoning air and water. "When you live in a cocktail of heavy metals or chemicals, your body struggles every day to survive," says Richard Fuller, head of the Blacksmith Institute, an environmental nonprofit. The group's annual report on the world's most polluted places aims to unite government, industry, and citizens to clean up toxic sites. The shock tactic can be effective. Haina, Dominican Republic, has left the top ten list: Media coverage of ongoing lead contamination from a former car-battery plant has prompted a public-private effort to clean up afflicted neighborhoods. —*Shelley Sperry*

Liquid slag sears a hill in Norilsk, Russia.

PHOTO: GERD LUDWIG. MAP SOURCE: BLACKSMITH INSTITUTE. NGM MAPS

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## Mines vs. Mussels

In southern Appalachian rivers, freshwater mussels play the role of canary in a coal mine: If they die, the river is in serious trouble. Today, along humid reaches of the Clinch River in Virginia and Tennessee, it's the mines that are killing the mussels, a danger sign for one of the nation's most biologically diverse watersheds.

Runoff from area strip mines appears a leading cause in decimating mussels on stretches of the Clinch and neighboring Powell River. Some 40 species, many of them rare, live up to 80 years buried in sand and gravel at the river's bottom. Said to taste like rubber, they filter sediments from the Clinch, which provides drinking water for nearby towns. The filtering also makes possible rich stocks of fish. But pollutants are overwhelming the mussels. Population density on parts of the Clinch has slid from 12 per square meter to less than half that amount. Some colonies are being restocked with juveniles to revive them, but without stricter enforcement of water-quality rules, warns biologist Steve Ahlstedt, "the river will be killed." *—Tom O'Neill*

**SHELL-SHOCKED**

The rough pigtoe (above) is one of 14 endangered mussel species threatened by mine runoff.

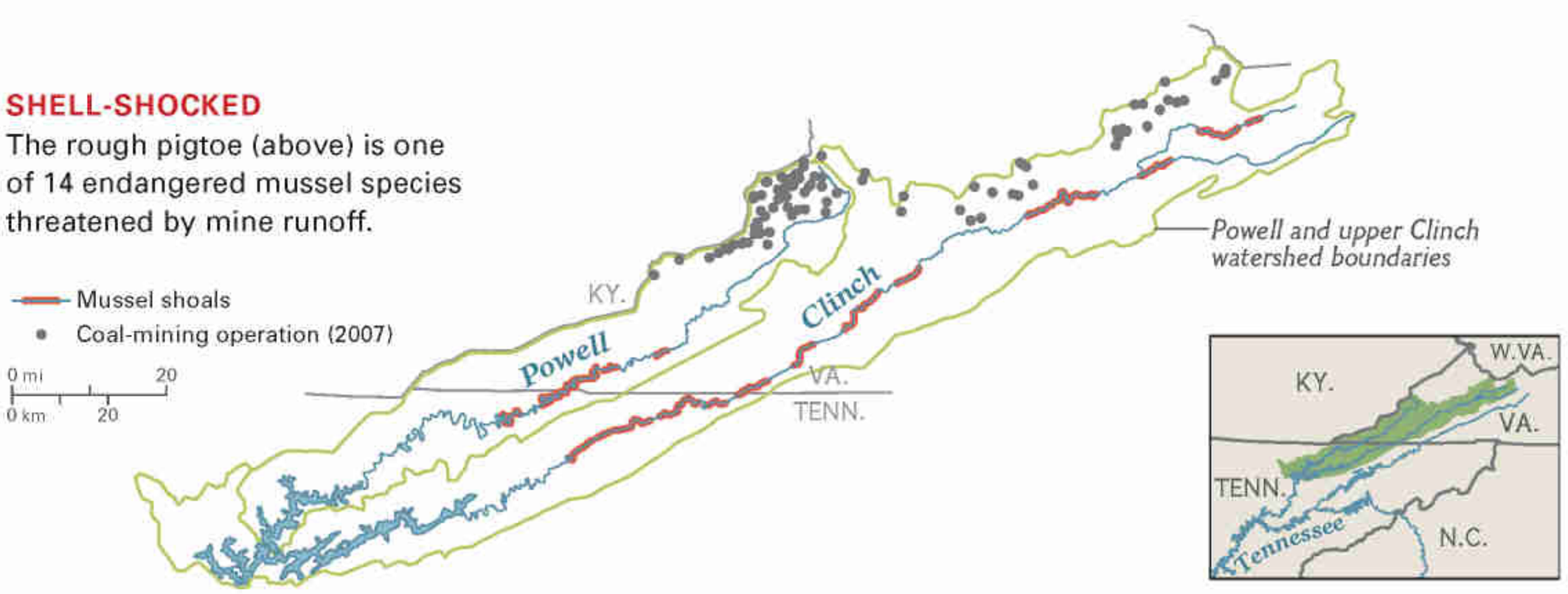


PHOTO: JOEL SARTORE. MAP SOURCES: THE NATURE CONSERVANCY; VIRGINIA DEPARTMENT OF MINES, MINERALS, AND ENERGY. NGM MAPS


On May 29, 1953, at 11:30 a.m., Sir Edmund Hillary and Sherpa Tenzing Norgay became the first men to stand on the summit of Mount Everest. But the top of the mountain was just the beginning of Sir Edmund's journey. More than half a century later, his efforts have resulted in the construction of schools, hospitals, medical clinics, bridges and freshwater pipelines for the people of the Himalayas. He may have left his footprint on a mountain, but he put his indelible imprint on the world.

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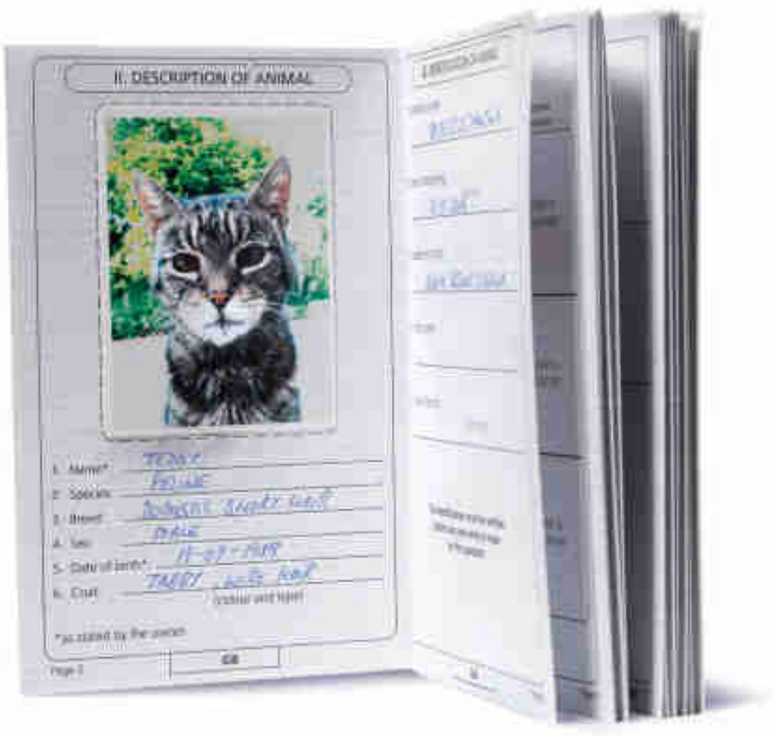
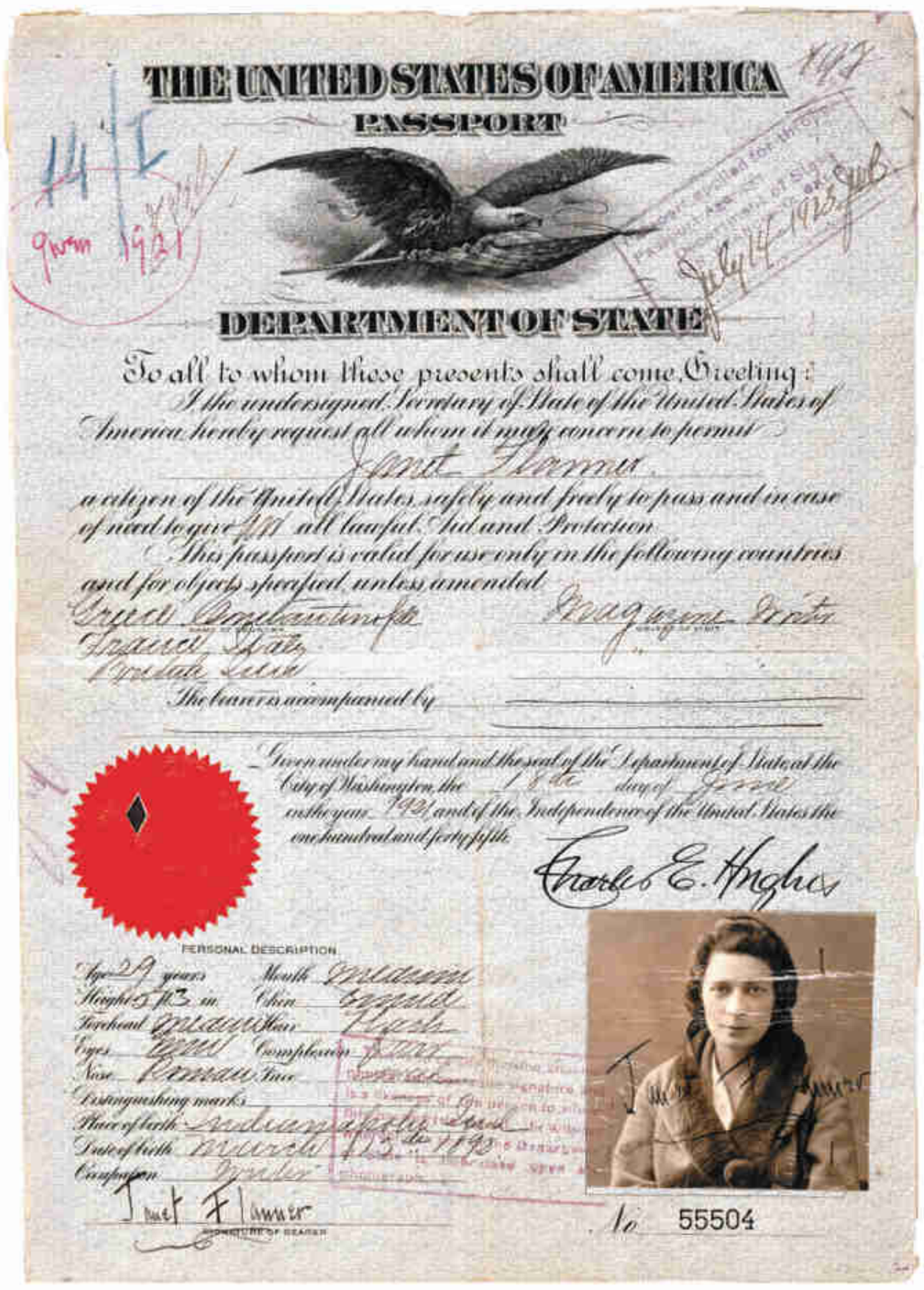
**Rites of Passport** At a time of tightened security, the passport is more essential than ever. Airborne Americans now must show one when returning from Canada, Mexico, and nearby islands. As a result, the U.S. passport office anticipates a record 16 million applications in 2007. That's a far cry from many centuries ago, when a passport, if required, was often a request for safe passage signed by a sovereign. Passports did catch on, but a late 1800s travel boom in Europe so overwhelmed passport issuers that most countries there eliminated the document. During World War I, the need to control border crossings revived the passport. Many countries, including the U.S., now implant a data chip in the booklet that can store your name, photo, and more. This has given rise to a new travel accessory: a special passport sleeve to block cyber ID thieves. —*A. R. Williams*




**2006 EUROPEAN UNION**
British tabby Teddy Tappin needed a pet passport to move to France.




**1921 UNITED STATES** Janet Flanner, a contributor to the *New Yorker,* traveled to Europe on this passport—one of more than 1,184,000 issued in the U.S. between 1912 and 1925.

**13TH-CENTURY CHINA**
A bronze *paiza* offered safe passage throughout the Mongol Empire.

**1854 CHINA** This document got the British ship *Jin Jun Yuan* from Zhejiang Province to Shanghai.

PHOTOS (CLOCKWISE FROM TOP): REBECCA HALE, NGS STAFF; JAMES L. STANFIELD, NATIONAL GEOGRAPHIC IMAGE COLLECTION; ASIAN AMERICAN STUDIES COLLECTION AT ETHNIC STUDIES LIBRARY, UNIVERSITY OF CALIFORNIA, BERKELEY; LIBRARY OF CONGRESS

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# EXPEDITIONS

**Diving for Distance** In January, after nearly five years of looking, cave divers Steve Bogaerts and Robbie Schmittner found a connection between two underwater caves in Mexico's Yucatán Peninsula, making Sac Actun—at 95 miles—the longest underwater cave system in the world. But the record didn't last. Nearby Ox Bel Ha, the longest known underwater cave system before the January 2007 discovery, was determined to be 102 miles in June. But Sac Actun could soon take the lead again.

The interlacing caves under the region are typically filled to the brim with water that seeps through the limestone. If you were an inch long, you could probably find connections between all the caves—one study found little genetic variation in one species of tiny, blind cave shrimp across the peninsula. But human cave divers have limits. They strap scuba tanks to their sides so they can squeeze through low passages. Dives typically last three to six hours and can go much longer. Dependent on life-support equipment, divers hang weightless in the dark, alien environment. "It's as close as you're going to get to being an astronaut," says Bogaerts. *—Helen Fields*


A diver swims in a cave under the Yucatán Peninsula (below). Stalactites and stalagmites form in the air, which means these caves used to be dry—about 18,000 years ago.

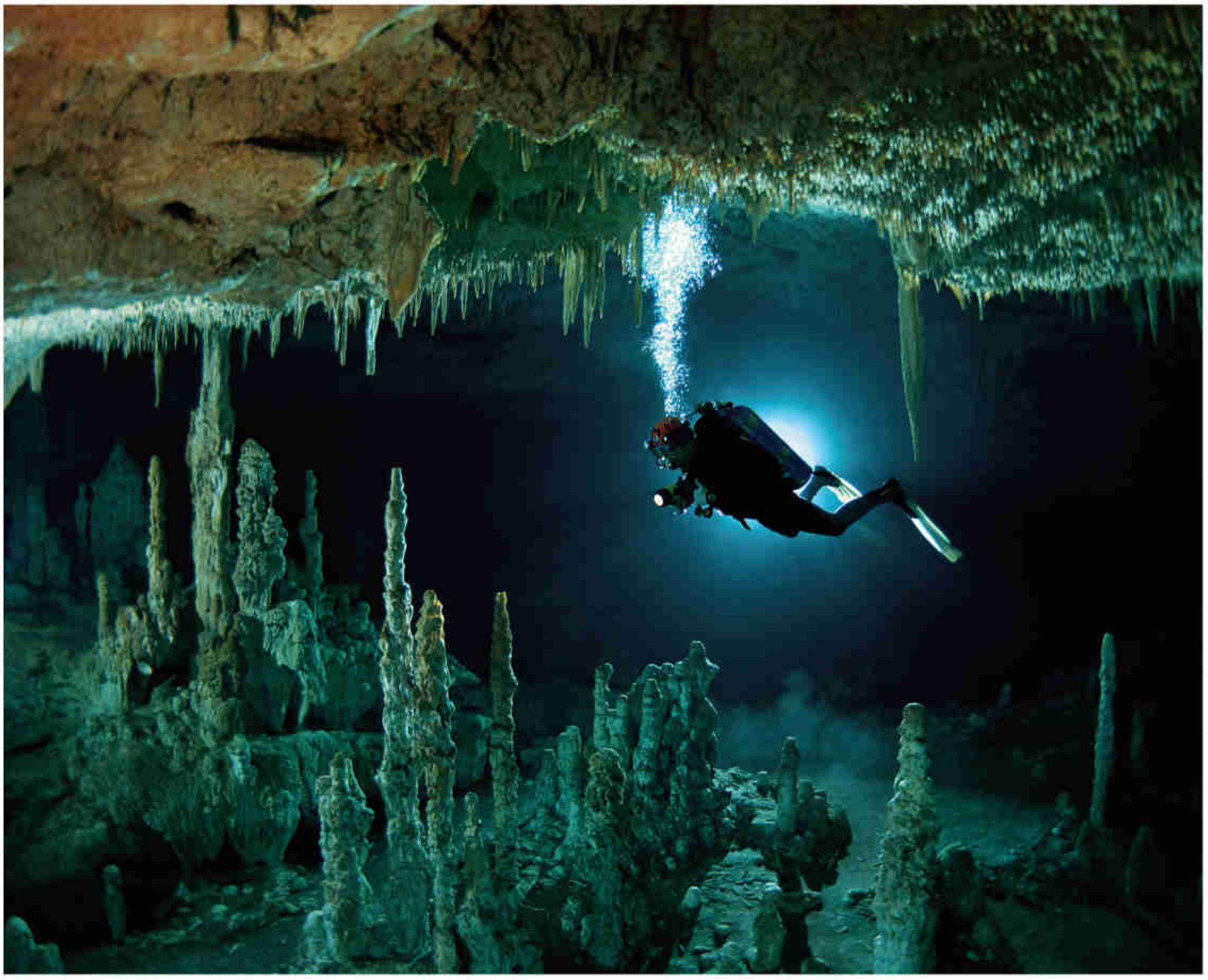
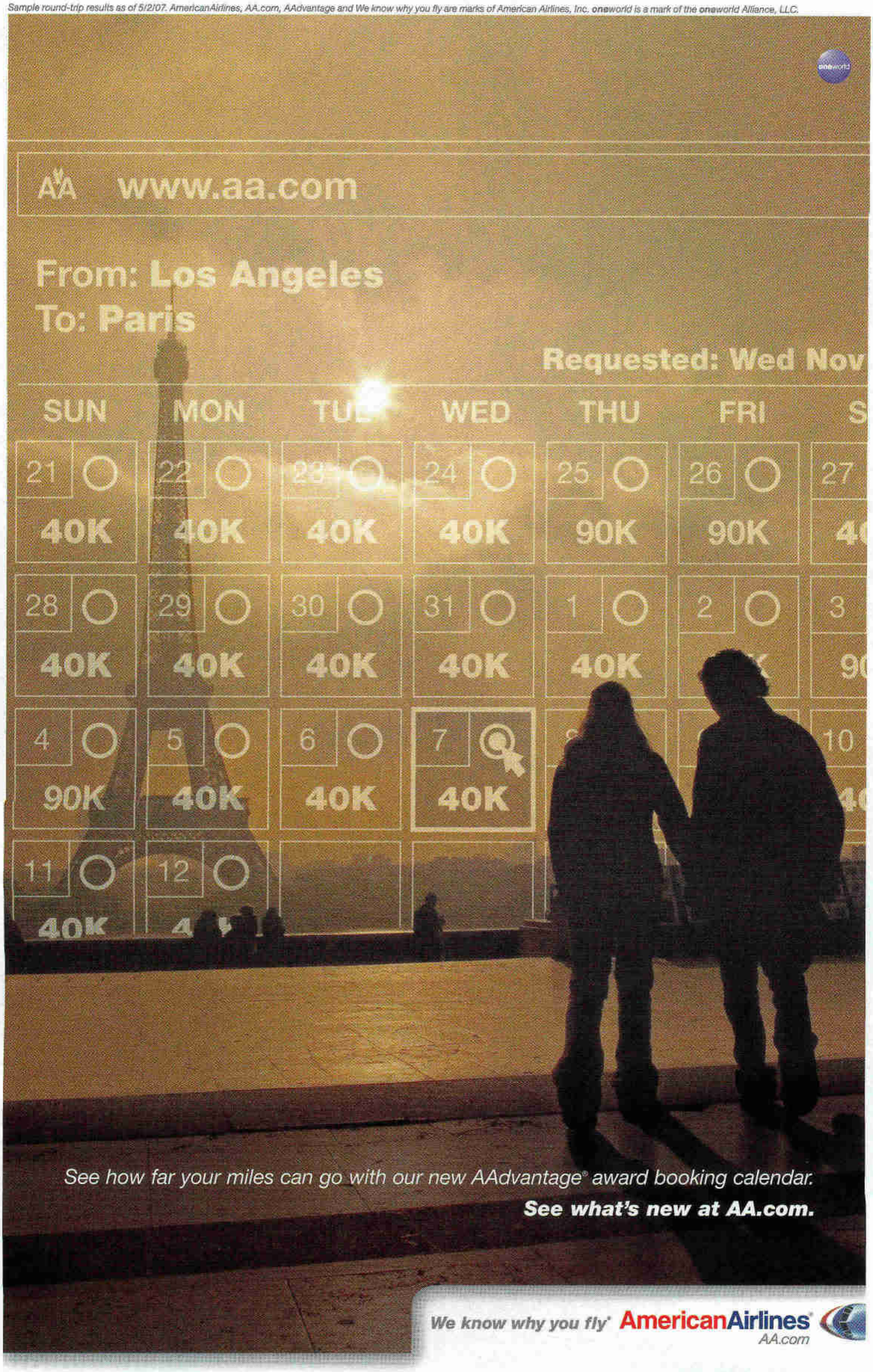


PHOTO: GAVIN NEWMAN

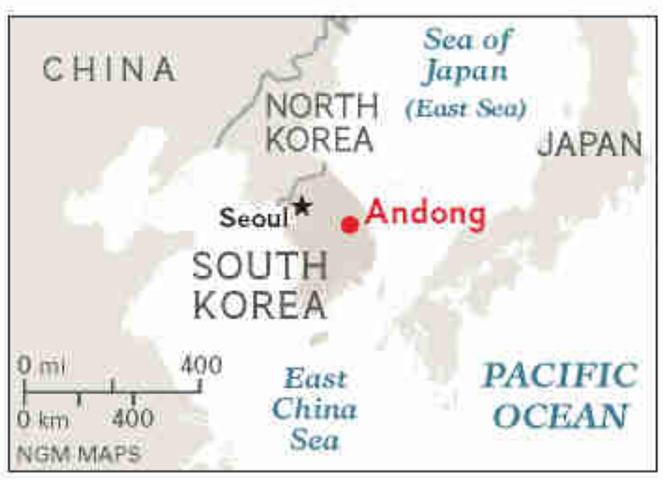
*Sample round-trip results as of 5/2/07. AmericanAirlines, AA.com, AAdvantage and We know why you fly are marks of American Airlines, Inc. **one**world is a mark of the **one**world Alliance, LLC.*



**Locks of Love** A mournful note and a pair of sandals from the 16th century have captivated South Korea. On June 1, 1586, a pregnant widow in the east wrote to her husband: "You always said you wanted to live with me until our hair turns gray. How could you pass away without me?" She left the letter in his tomb, along with shoes she'd made as a sign of love for her ailing spouse, woven from her hair and hemp bark. There they lay until the city of Andong began moving graves to make way for houses.

Her message was that love transcends time and place. "Come to me secretly," she urged. "Although I have so much to say, I'll stop here." Korea has resurrected the dialogue with two novels and a TV documentary. A statue of the widow stands at the grave site. Koreans and Japanese tourists have bought thousands of copies of the letter. "It is a timeless piece," says Park Chang-gun, a professor directing an opera about the couple, "still making people cry." *—Neil Shea*

A young woman wove her hair into shoes for her mate. Buried in his tomb for centuries, they are now in a museum in Andong, South Korea.




PHOTOS: ANDONG NATIONAL UNIVERSITY MUSEUM

LIMPOPO: 29º 11' SOUTH, 31º 01' EAST

# CURIOSITY meets THE CAT

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**Baldness Business** This year marks the first time the U.S. Food and Drug Administration has cleared an anti-baldness device. The maker of a $545 laser comb submitted data for 123 men who ran the light-emitting contraption through thinning locks three times a week. Nine out of ten reported fewer hairs lost; some saw new growth. Dermatologists would like to see the study published in a peer-reviewed journal but aren't entirely skeptical. A rare side effect from laser hair removal, notes New York University dermatology professor Jerry Shapiro, is . . . hair growth! *—Marc Silver*

## REMEMBER THE MANE

For millennia, mankind has battled baldness.

**BIBLE DAYS** In the Book of Kings, mean kids call Prophet Elisha "baldhead." The humiliated Hebrew is said to have slapped bear grease on his pate as a remedy. For centuries, other bald men do the same. Their rationale: Bears are very hairy.

**50 B.C.** Julius Caesar's laurel wreath? It's his version of a toupee.

**1940s** Rest easy, male-pattern bald man. You did not cause your condition by emitting heat from thinking too hard or, as Samuel Johnson proposed in 1778, by having a "dry" brain. Nor is it the fault of dandruff or air pollution, as some thought. Research points to heredity and hormones.

**1950s** A New York doctor moves plugs of hair from a fecund area to a bald patch, where the hairs follow genetic orders: Sprout! Thus begins the era of hair transplantation.

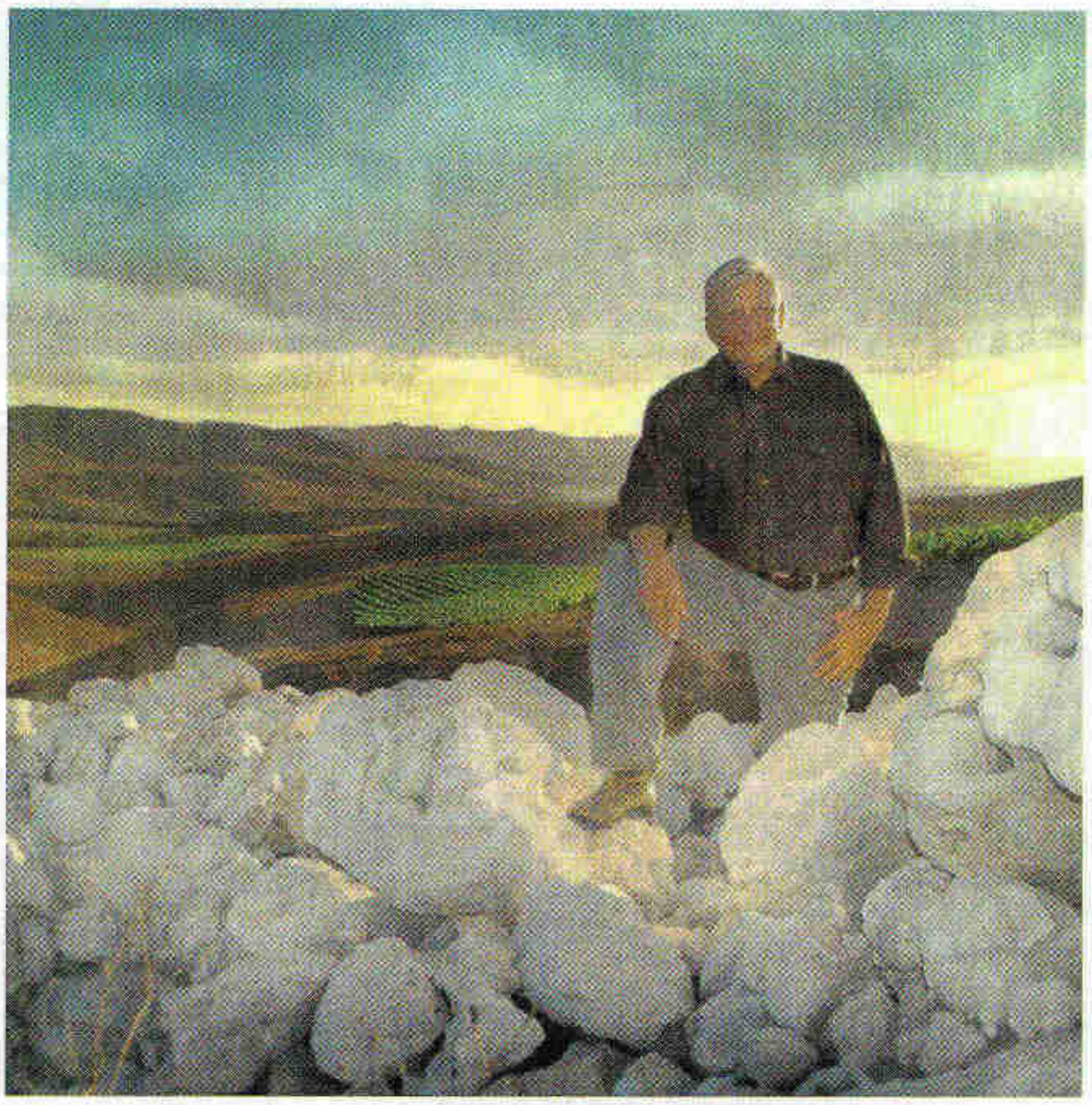
**1988** The FDA approves minoxidil, an ointment applied to the scalp to stop hair loss and stimulate growth. Dermatologists say two-thirds of balding patients see minimal to moderate improvement. Women reportedly get better results.

**1990s** Hair in a Can hopes guys will pay to spray their scalp the color of remaining hair. But the stylish baldness of basketball star Michael Jordan launches a head-shaving craze.

**1997** Finasteride, the first prescription pill for balding men, gets FDA OK. According to one study, the prostate drug derivative offers a 75 percent chance of halting loss for men 18 to 40, a 37 percent chance of regrowth at the scalp's front.

**2010** That's when Neil Sadick, a Cornell dermatology professor, foresees hair cell "multiplication." If one wee follicle could carpet a gleaming dome, no one need be bald again. Just don't expect insurance to pay.

PHOTO: REBECCA HALE, NGS STAFF
SOURCE: KERRY SEGRAVE, *BALDNESS: A SOCIAL HISTORY*



*Jess Jackson, Camelot Highlands Estates, Santa Maria Valley*

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Many of you enjoy the taste of our wines but are not sure why. My goal is to help with **A Taste of the Truth.**

Jess S Jackson

kj.com/truth

**Turtles Snap Back** A turtle with a bone-crushing bite and a strike as fast as a cobra's seems as if it would be king of the river. But it had been years since anyone spotted a breeding population of the endangered Cantor's giant softshell turtle, which was no match for hunters or people excavating its eggs from sandy riverbanks. Yet when conservationists pulled up a trap from northern Cambodia's Mekong River, there it was: a 24-pounder with a distinctive low profile and a shell of rubbery skin stretched over fused ribs. The survey team found three adults and 12 hatchlings. "I could scarcely believe it," says David Emmett of Conservation International. The turtle, which mainly spends its time dug into river bottoms, once lived across much of Asia. Until the late 1990s, the presence of the brutal Khmer Rouge kept many people away from the 31-mile stretch of river where the turtle turned up. Now, land-hungry migrants are pouring in; a planned dam could also threaten turtle habitat. If some of the area isn't declared off-limits, warns Mark Bezuijen of the World Wildlife Fund, the flat reptile may vanish as quickly as it resurfaced. *—Karen E. Lange*

Rare sights: A female old enough to be a mother (top) and six-day-old babies, whose hatching was overseen by conservationists.


PHOTOS: DAVID EMMETT (TOP); ANNETTE OLSSON

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Lolo Escobar is a subsistence farmer in Chile's Puelo River Valley.


## RESOURCES AT RISK

- **Local agriculture** Temperature fluctuations associated with the dam's giant reservoir may disturb farming.
- **Flora and fauna** Threatened species include alerce, Patagonian cypress, and the endangered Andean deer.
- **Aquaculture** Puelo fresh water feeds salmon farms on Reloncaví Sound.

**Damming the Puelo River** Visitors to Chile's Puelo River Valley find a swollen, turquoise river twisting through stands of southern beech, hemmed in by glacial peaks. These natural barriers have helped keep the valley pristine.

Now, construction of a huge hydroelectric project threatens to change the region forever. Spurred by Chile's fears of an energy crisis, the Spanish-owned power company Endesa has plans for a series of large-scale dams in Chilean Patagonia. In the Puelo Valley, one of the proposed dams would flood 12,000 acres and displace the population. Endesa supporters hope the project will bolster the economy. Others think it's unnecessary because existing resources could be used more efficiently. Chile's citizens currently use almost a third of the nation's electric energy supply. More than half is consumed by industry and mining.

Endesa claims the Puelo project is still under study, though Wolfram Heise of Conservacion Patagonica says, "Of all the planned dam projects, the Puelo probably will be the fastest to go." Now Puelo area residents, used to isolation—without telephones or a post office—are scrambling to make their opposition known. Even if they are compensated for losing their land, residents worry about finding the same quality of life elsewhere. Subsistence farmer Tito Cuevas Mansilla says, "We have very little, but it is enough to live on. And no one wants to leave even the little they have for a dam." *—Carolyn McCarthy*

PHOTO: JOSH STEPHENSON

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## Tongue Twisters

Eat the white flesh of a red berry called miracle fruit (below), then suck a lemon slice. For many folks, the taste will be as sugary as a piece of candied peel. The reason is a compound called miraculin, named for the fruit. Scientists say it seems to bind to the tongue's sweet receptors; introducing a sour food activates those receptors. Native to West Africa, the miracle fruit is gaining favor in the U.S. as a party trick and as a sugarless way to sweeten foods. But a 1970s effort to make no-sugar treats with a berry additive ended when the FDA asked for years of tests to ensure safety. The artichoke (left) has a similar syrupy effect. A compound, cynarin, tinkers with sweet receptors. Water rinses it away, turning receptors on for a hint of sugar in the drink. But the choke can't match the miracle fruit. It's "extraordinary," says Tim Jacob, a physiology professor at Cardiff University in Wales. Indeed: In the U.S., the berries sell for nearly two dollars each. *—Catherine L. Barker*

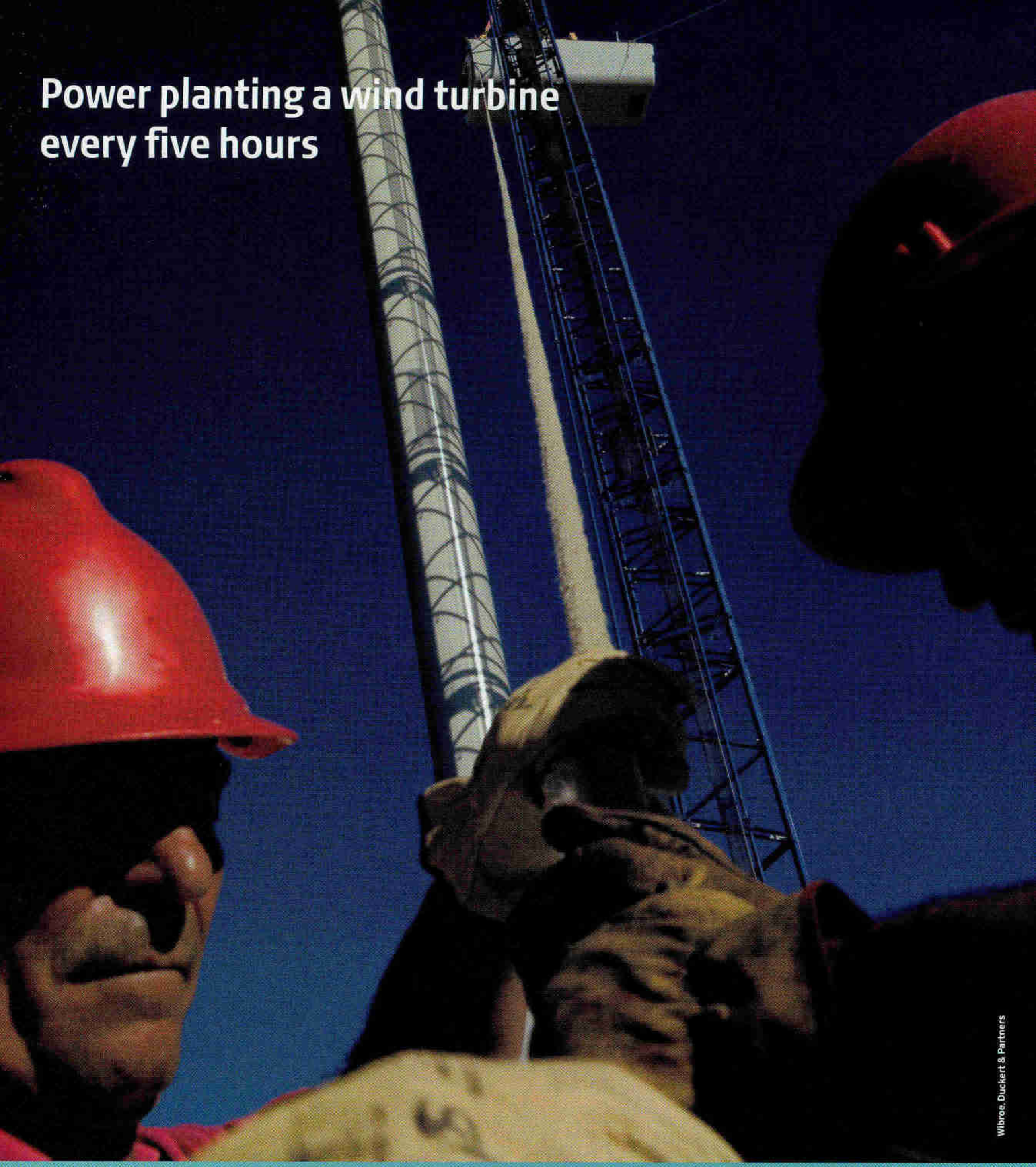
### TASTING MENU

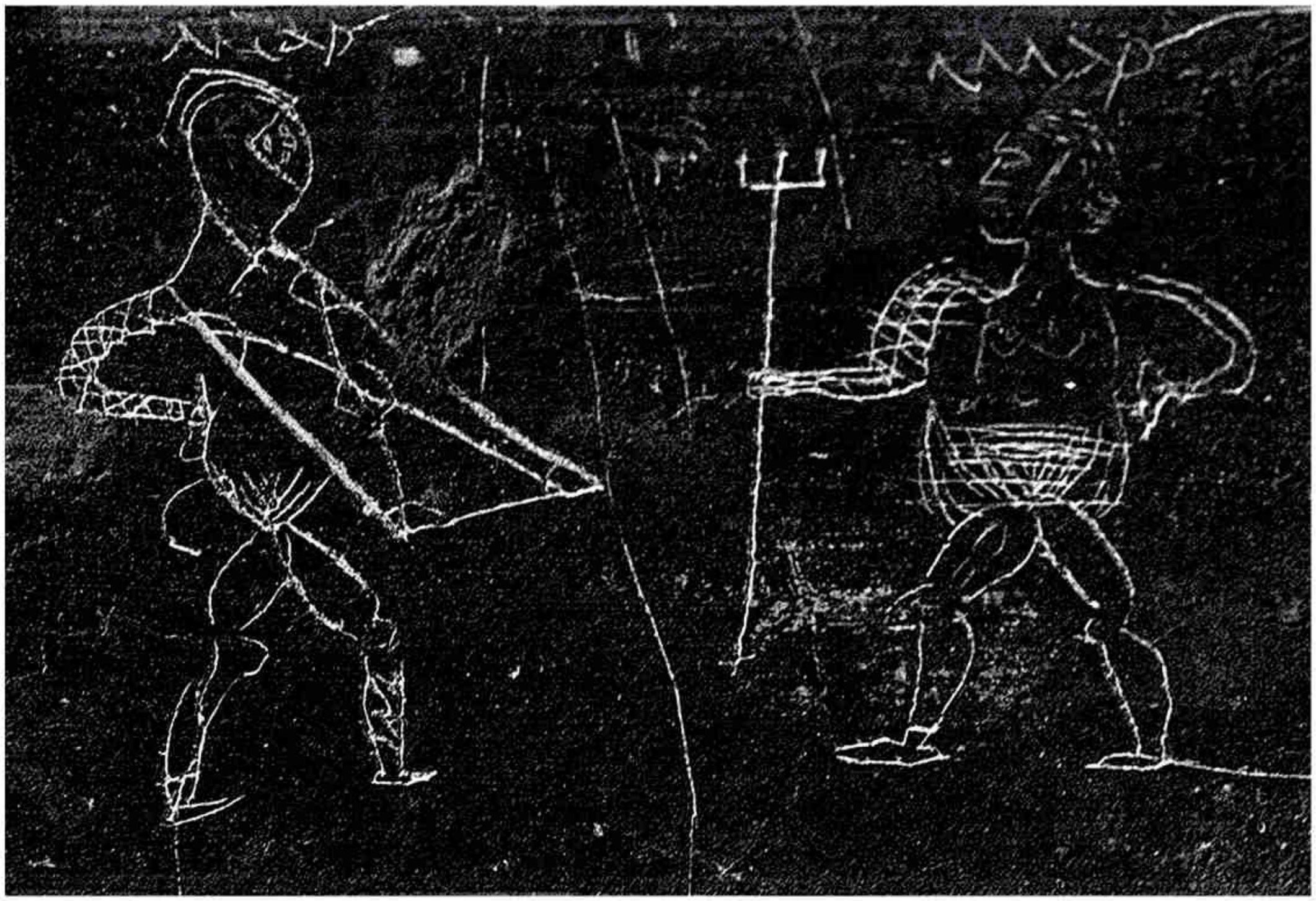
- **Papillae** are the visible red dots on the tongue's surface.
- **Taste buds** are microscopic clusters of cells on the papillae.
- **Taste receptors** sit on the buds.
- **Five tastes** are detected by receptors: sweet, salty, bitter, sour, and umami, or savory, a term coined in 1909 by a Japanese scientist for a meaty, mouth-filling flavor.



The jelly-bean-size miracle fruit and the artichoke both wield power over taste buds.

PHOTOS: REBECCA HALE, NGS STAFF



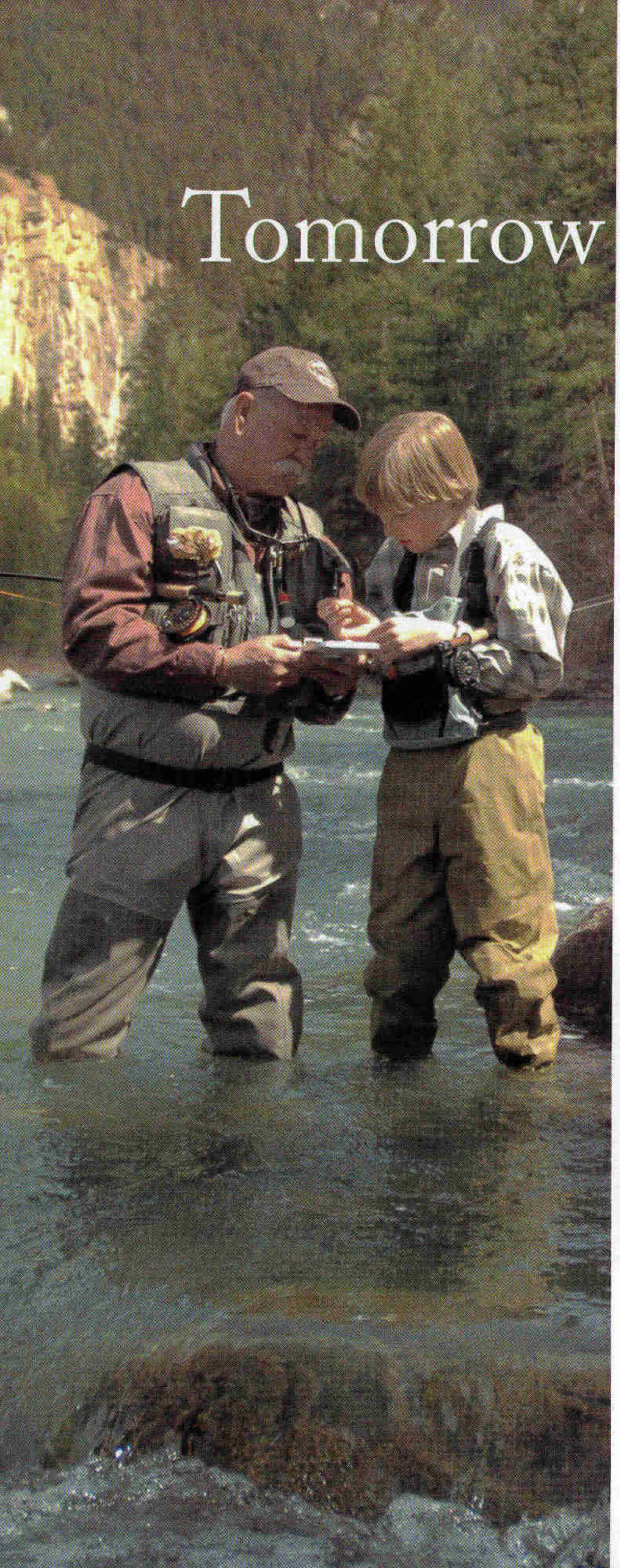


Trident meets shield in this graffiti (above) from a wealthy home in Ephesus.

**Gladiators From the Grave** The gladiators buried in a mass grave in the ancient city of Ephesus have cast new light on lives that were less brutish than you might think, confirming what historians had learned from Roman writings and inscriptions.

Injuries on the skeletons, which date from the third century A.D., prove they were gladiators. One skull has two holes spaced at the same distance as the prongs of a trident (right) found at the site of the Ephesus harbor, and other injuries match other kinds of weapons. But fights were not always to the death—the men had survived many injuries and showed signs of excellent care. One arm bone had healed so neatly that the researchers, anthropologists from the Medical University of Vienna, had to do scans back in Austria to be sure it had been broken. Bone chemistry confirmed that the men ate little meat, while muscle markers prove they exercised rigorously. After such training, it was hardly economical to let the men fight to the death. "They were popular, and if they were clever, they were also able to earn a lot of money," says physical anthropologist Fabian Kanz. Gladiator careers could last years; successful gladiators sometimes even won their freedom. *—Helen Fields*


PHOTOS: W. PIETSCH, ÖAI (TOP); A. KRINZINGER, ÖAI

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# WHERE IN THE WORLD?

Sand blown in from the 60-mile-long Athabasca dune fields adds color and stripes to Saskatchewan's William River.

**Sand Bands** This braided whip of caramel is a turn in Saskatchewan's William River. Why so brown? The white wedge (upper left) and doughnut (lower left) get credit. They're part of Athabasca Sand Dunes Provincial Wilderness Park, Canada's largest active dune fields. As the river flows by, west winds blow in loads of quartz sand. Tan sand flats are exposed by low water levels; darker sandbars striate the bed. Other colors to decode: Bogs are light green, pine is dark green. And the curious khaki curl above the river is a previous meander, now dry. *—Jennifer S. Holland*

PHOTO: EAMON MAC MAHON

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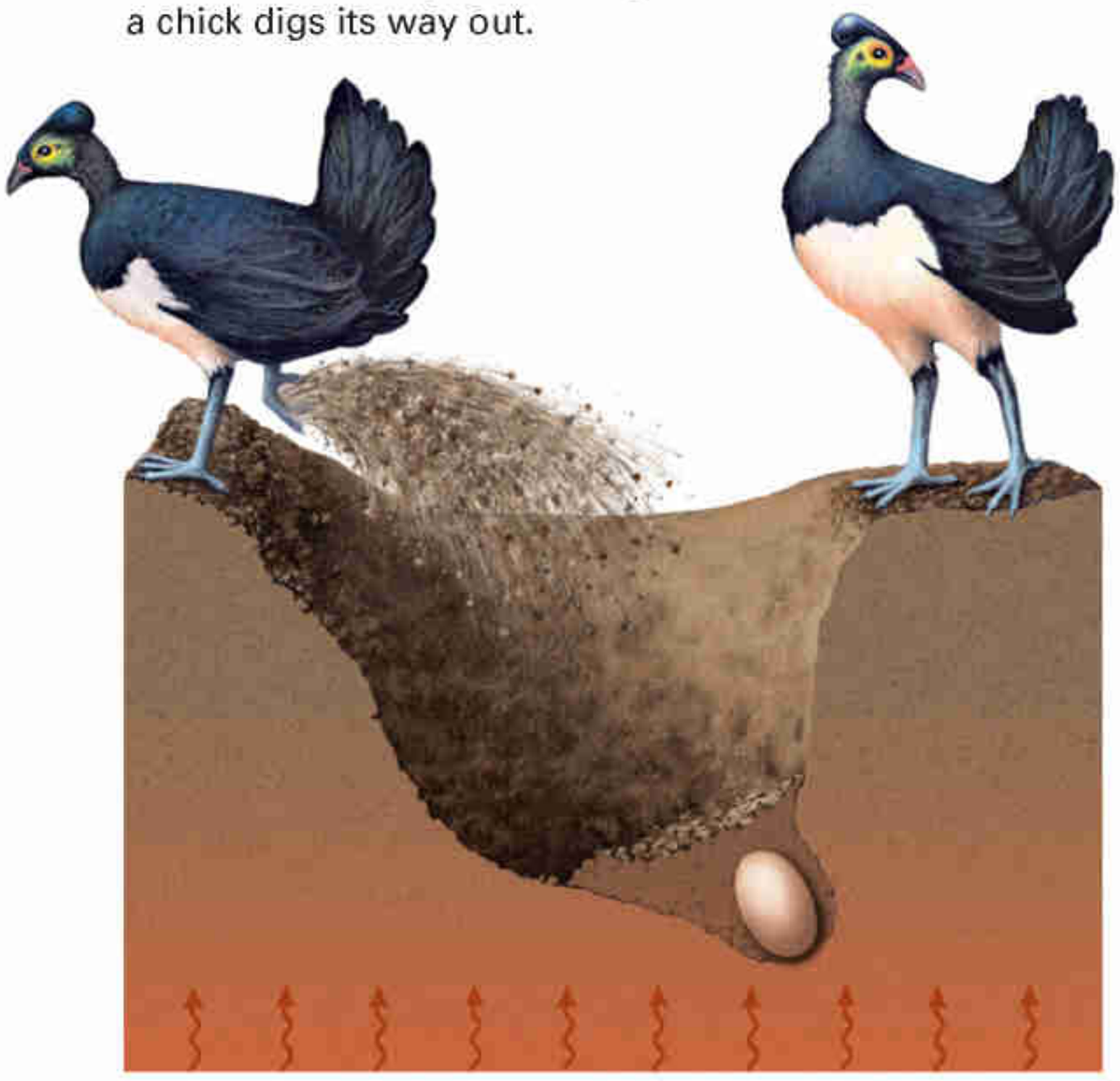
Hom will you please let me borrow your car tonight?

A rare captive maleo bird laid this egg at the Bronx Zoo, which is run by the Wildlife Conservation Society.

Lay it, bury it, forget about it. For about 70 days, maleo bird eggs incubate under sand or rain forest soil. Upon hatching, a chick digs its way out.



NG GRANTEE

## Poached Eggs

On the Indonesian island of Sulawesi, the old way of making maleo birds isn't working anymore. Females, which don't stick around to raise their young, bury eggs under sand or rain forest soil, where sun or geothermal heat keeps developing embryos warm. Problem is, people often find the eggs and eat them. Now as few as 5,000 of the birds remain. To protect endangered maleos, the Wildlife Conservation Society—with funding from National Geographic—is trying to preserve the nest sites where the WCS can choose to transfer eggs to guarded hatcheries. Since 2001, WCS has released more than 4,000 chicks. In the future, the group hopes to safeguard the critical corridors connecting maleo nesting beaches to rain forest. *—Alan Mairson*


PHOTO: IRA BLOCK. ART: JEN CHRISTIANSEN. NGM MAPS

# REMEMBER

# THIS

IN THE ARCHIVES OF THE BRAIN,

OUR LIVES LINGER OR DISAPPEAR.

In the sea of memory Elly Chovel found purpose. At 14 she was a frightened refugee from Castro's Cuba. At 43 she helped create an organization to aid children in need, and to preserve the history of 14,000 Cuban children who fled to the U.S. without parents between 1960 and 1962. "From memories of suffering comes compassion," she says.

BY JOSHUA FOER

PHOTOGRAPHS BY MAGGIE STEBER

There is a 41-year-old woman, an administrative assistant from California known in the medical literature only as "AJ," who remembers almost every day of her life since age 11. There is an 85-year-old man, a retired lab technician called "EP," who remembers only his most recent thought. She might have the best memory in the world. He could very well have the worst.

"My memory flows like a movie—nonstop and uncontrollable," says AJ. She remembers that at 12:34 p.m. on Sunday, August 3, 1986, a young man she had a crush on called her on the telephone. She remembers what happened on *Murphy Brown* on December 12, 1988. And she remembers that on March 28, 1992, she had lunch with her father at the Beverly Hills Hotel. She remembers world events and trips to the grocery store, the weather and her emotions. Virtually every day is there. She's not easily stumped.

There have been a handful of people over the years with uncommonly good memories. Kim Peek, the 56-year-old savant who inspired the movie *Rain Man,* is said to have memorized nearly 12,000 books (he reads a page in 8 to 10 seconds). "S," a Russian journalist studied for three decades by the Russian neuropsychologist Alexander Luria, could remember impossibly long strings of words, numbers, and nonsense syllables years after he'd first heard them. But AJ is unique. Her extraordinary memory is not for facts or figures, but for her own life. Indeed, her inexhaustible memory for autobiographical details is so unprecedented and so poorly understood that James McGaugh, Elizabeth Parker, and Larry Cahill, the neuroscientists at the University of California, Irvine, who have been studying her for the past seven years, had to coin a new medical term to describe her condition: hyperthymestic syndrome.

EP is six-foot-two, with perfectly parted white hair and unusually long ears. He's personable,

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The 85-year-old California man researchers call "EP" dwells almost entirely in the present tense. A brain infection wiped out decades of memories, along with the capacity to create new ones.

friendly, gracious. He laughs a lot. He seems at first like your average genial grandfather. But 15 years ago, the herpes simplex virus chewed its way through his brain, coring it like an apple. By the time the virus had run its course, two walnut-size chunks of brain matter in the medial temporal lobes had disappeared, and with them most of EP's memory.

The virus struck with freakish precision. The medial temporal lobes—there's one on each side of the brain—include a curved structure called the hippocampus and several adjacent regions that together perform the magical feat of turning our perceptions into long-term memories. The memories aren't actually stored in the hippocampus—they reside elsewhere, in the brain's corrugated outer layers, the neocortex—but the hippocampal area is the part of the brain that makes them stick. EP's hippocampus was destroyed, and without it he is like a camcorder without a working tape head. He sees, but he doesn't record.

EP has two types of amnesia—anterograde, which means he can't form new memories, and retrograde, which means he can't remember old memories either, at least not since 1960. His childhood, his service in the merchant marine, World War II—all that is perfectly vivid. But as far as he knows, gas costs less than a dollar a gallon, and the moon landing never happened.

AJ and EP are extremes on the spectrum of human memory. And their cases say more than any brain scan about the extent to which our memories make us who we are. Though the rest of us are somewhere between those two poles of remembering everything and nothing, we've all experienced some small taste of the promise of AJ and dreaded the fate of EP. Those three pounds or so of wrinkled flesh balanced atop our spines can retain the most trivial details about childhood experiences for a lifetime but often can't hold on to even the most important telephone number for just two minutes. Memory is strange like that.

What is a memory? The best that neuroscientists can do for the moment is this: A memory is a stored pattern of connections between neurons in the brain. There are about a hundred billion of those neurons, each of which can make perhaps 5,000 to 10,000 synaptic connections with other neurons, which makes a total of about five hundred trillion to a thousand trillion synapses in the average adult brain. By comparison there are only about 32 trillion bytes of information in the entire Library of Congress's print collection. Every sensation we remember, every thought we think, alters the connections within that vast network. Synapses are strengthened or weakened or formed anew. Our physical substance changes. Indeed, it is always changing, every moment, even as we sleep.

I met EP at his home, a bright bungalow in suburban San Diego, on a warm spring day. I drove there with Larry Squire, a neuroscientist and memory researcher at the University of California, San Diego, and the San Diego VA Medical Center, and Jen Frascino, the research coordinator in Squire's lab who visits EP regularly to administer cognitive tests. Even though Frascino has been to EP's home some 200 times, he always greets her as a stranger.

Frascino sits down opposite EP at his dining room table and asks a series of questions that gauge his common sense. She quizzes him about what continent Brazil is on, the number of weeks in a year, the temperature water boils at. She wants to demonstrate what IQ tests have already proved: EP is no dummy. He patiently answers the questions—all correctly—with roughly the

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*Joshua Foer's book about the art and science of memory will be published in 2009. Maggie Steber grew up with her mother, Madje, a parasitologist, in Austin, Texas.*

same sense of bemusement I imagine I would have if a total stranger walked into my house, sat down at my table, and very earnestly asked me if I knew the boiling point of water.

"What is the thing to do if you find an envelope in the street that is sealed, addressed, and has a stamp on it?" Frascino asks.

"Well, you'd put it in the mailbox. What else?" He chuckles and shoots me a sidelong and knowing glance, as if to say, Do these people think I'm an idiot? But sensing that the situation calls for politeness, he turns back to Frascino and adds, "But that's a really interesting question you've got there. Really interesting." He has no idea he's heard it many times before.

"Why do we cook food?"

"Because it's raw?" The word raw carries his voice clear across the tonal register, his bemusement giving way to incredulity.

"Why do we study history?"

"Well, we study history to know what happened in the past."

"But why do we want to know what happened in the past?"

"Because, it's just interesting, frankly."

EP wears a metal medical alert bracelet around his left wrist. Even though it's obvious what it's for, I ask him anyway. He turns his wrist over and casually reads it.

"Hmm. It says memory loss."

EP doesn't even remember that he has a memory problem. That is something he discovers anew every moment. And since he forgets that he always forgets, every lost thought seems like just a casual slip—an annoyance and nothing more—the same way it would to you or me.

HE DOESN'T EVEN REMEMBER THAT HE HAS A MEMORY PROBLEM. That is something he discovers anew every moment. And since he forgets that he always forgets, every lost thought seems like just a casual slip—an annoyance and nothing more.

Ever since his sickness, space for EP has existed only as far as he can see it. His social universe is only as large as the people in the room. He lives under a narrow spotlight, surrounded by darkness.

On a typical morning, EP wakes up, has breakfast, and returns to bed to listen to the radio. But back in bed, it's not always clear whether he's just had breakfast or just woken up. Often he'll have breakfast again, and return to bed to listen to some more radio. Some mornings he'll have breakfast a third time. He watches TV, which can be very exciting from second to second, though shows with a clear beginning, middle, and end can pose a problem. He prefers the History Channel, or anything about World War II. He takes walks around the neighborhood, usually several times before lunch, and sometimes for as long as three-quarters of an hour. He sits in the yard. He reads the newspaper, which one can only imagine must feel like stepping out of a time machine. Bush who? Iraq what? Computers when? By the time EP gets to the end of a headline, he's usually forgotten how it began. Most of the time, after reading the weather, he just doodles on the paper, drawing mustaches on the photographs or tracing his spoon. When he sees home prices in the real estate section, he invariably announces his shock.

Without a memory, EP has fallen completely out of time. He has no stream of consciousness, just droplets that immediately evaporate. If you were to take the watch off his wrist—or, more cruelly, change the time—he'd be completely lost. Trapped in this limbo of an eternal present, between a past he can't remember and a future he can't contemplate, he lives a sedentary life, completely free from worry. "He's happy all the time. Very happy. I guess it's because he doesn't

Mary Farnham loves green. When memory loss made it unsafe for her to live alone, she moved to Oatfield Estates, a residential-care facility near Portland, Oregon, and promptly began putting her stamp on her surroundings. "Mary didn't just pick the color," explains staff member Nancy Wolske, "she picked up a brush." The 83-year-old artist continues to paint, draw, and show her work. Intellectual and social engagement, many researchers believe, helps slow mental decline. "We have to rethink every single component of how we're caring for our elders," says Wolske, because "the people they were are still there."

PRESERVING HER PAST HAS BECOME THE CENTRAL COMPULSION OF HER LIFE.

"When I'm drying my hair I'll think of whatever day it is. To pass the time, I'll just run through that day in my head over the last 20-something years—like flipping through a Rolodex."

have any stress in his life," says his daughter, Carol, who lives nearby.

"How old are you now?" Squire asks him.

"Let's see, 59 or 60. You got me. My memory is not that perfect. It's pretty good, but sometimes people ask me questions that I just don't get. I'm sure you have that sometimes."

"Sure, I do," says Squire, kindly, even though EP is almost a quarter of a century off.

An enormous amount of what science knows about memory was learned from a damaged brain that is remarkably similar to EP's. It belongs to an 81-year-old man known as "HM," an amnesiac who lives in a nursing home in Connecticut. HM suffered from epilepsy that began at age ten after a bike accident. By the time he was 27, he was blacking out several times a week and unable to do much of anything. A neurosurgeon named William Beecher Scoville thought he could relieve HM's symptoms with an experimental surgery that would excise the part of the brain that he suspected was causing the problem.

In 1953, while HM lay awake on the operating table, his scalp anesthetized, Scoville drilled a pair of holes just above the patient's eyes. The surgeon lifted the front of HM's brain with a small metal spatula while a metal straw sucked out most of the hippocampus, along with much of the surrounding medial temporal lobes. The surgery reduced the frequency of HM's seizures, but it soon became clear that it also robbed him of his memory.

Over the next five decades, HM was the subject of countless experiments and became the most studied patient in the history of brain science. Given the tragic outcome of Scoville's surgery, everyone assumed HM would be a singular case study.

EP shattered that assumption. What Scoville did to HM with a metal straw, nature did to EP with herpes simplex. Side by side, the grainy black-and-white MRIs of their brains are uncannily similar, though EP's damage is a bit more extensive. Even if you have no idea what a normal brain ought to look like, the gaping symmetrical holes stare back at you like eyes.

Like EP, HM was able to hold on to memories just long enough to think about them, but once his brain moved to something else, he could never bring them back. In one famous experiment, Brenda Milner, a Canadian psychologist, asked HM to remember the number 584 for as long as possible. To keep the number on the tip of his tongue, he used a complicated system, which he recounted to Milner:

"It's easy. You just remember 8. You see 5, 8, and 4 add to 17. You remember 8, subtract it from 17, and it leaves 9. Divide 9 in half and you get 5 and 4 and there you are: 584. Easy."

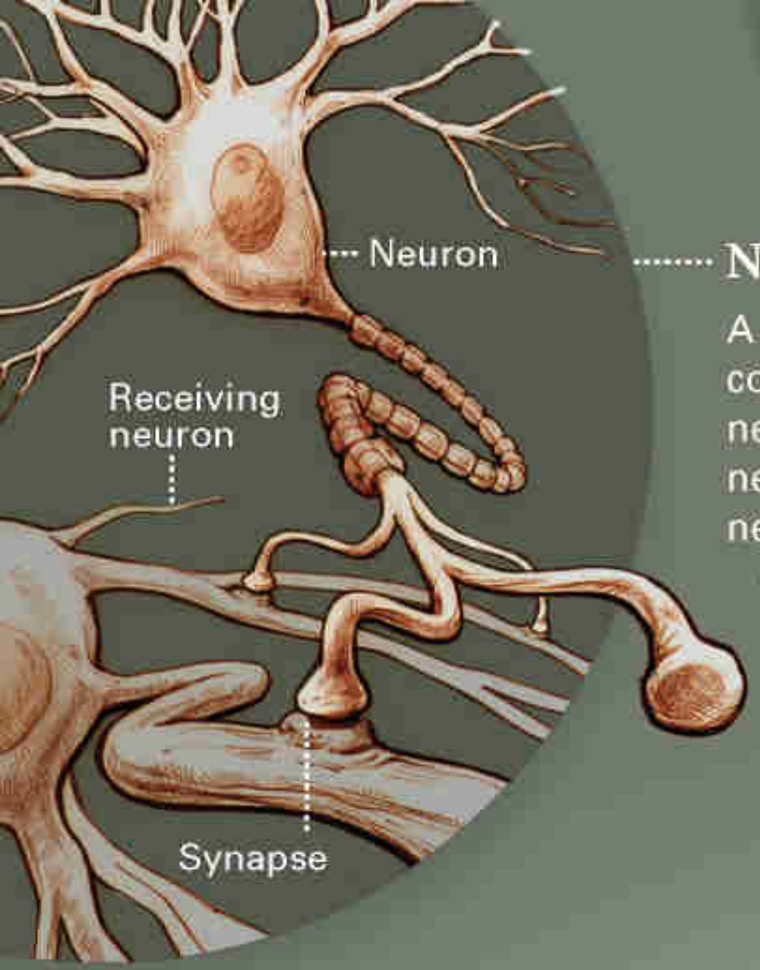
He concentrated on this elaborate mantra for several minutes. But as soon as he was distracted, the number dissolved. He couldn't even remember that he'd been asked to remember something. Though scientists had known that there was a difference between long- and short-term memory since the late 19th century, they now had evidence in HM that the two types of memory happened in different parts of the brain, and that without most of the hippocampal area, HM could not turn a short-term memory into a long-term one.

Researchers also learned more about another kind of remembering from HM. Even though

Words no longer come easily to Francis Zetterberg (at left), but he can still summon a lifetime of farming know-how. The 91-year-old puts his expertise to work at the side of his friend Melissa Richmond, Oatfield's gardening coordinator. Fruits and vegetables they grow together help supply residents' kitchens.

he couldn't say what he'd had for breakfast or name the current President, there were some things that he could remember. Milner found that he was capable of learning complicated tasks without even realizing it. In one study, she showed that HM could learn how to trace inside a five-pointed star on a piece of paper while looking at its reflection in a mirror. Each time Milner gave HM the task, he claimed never to have tried it before. And yet, each day his brain got better at guiding his hand to work in reverse. Despite his amnesia, he was remembering.

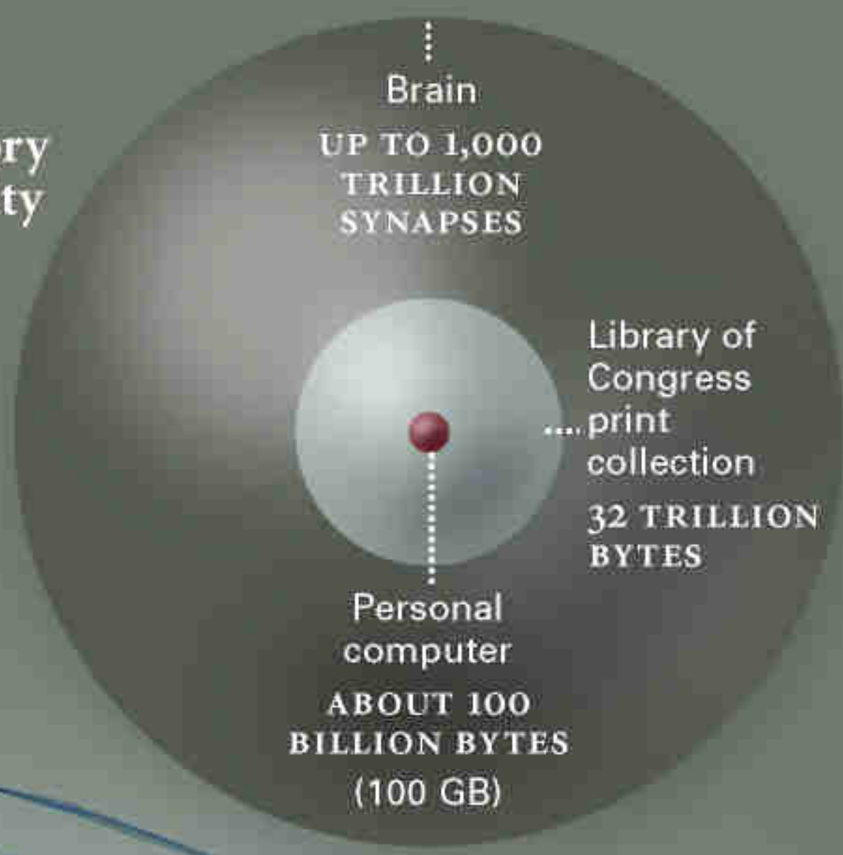
Though there is disagreement about just how many memory systems there are, scientists generally divide memories into two types: declarative and nondeclarative (sometimes referred to as explicit and implicit). Declarative memories are things you know you remember, like the color of your car or what happened yesterday afternoon. EP and HM have lost the ability to make new declarative memories. Nondeclarative memories are the things you know without consciously thinking about them, like how to ride a bike or how to draw a shape while looking at it in a mirror. Those unconscious memories don't rely on the hippocampal region to be consolidated and stored. They happen in completely different parts of the brain. Motor skill learning takes place at the base of the brain in the cerebellum, perceptual learning in the



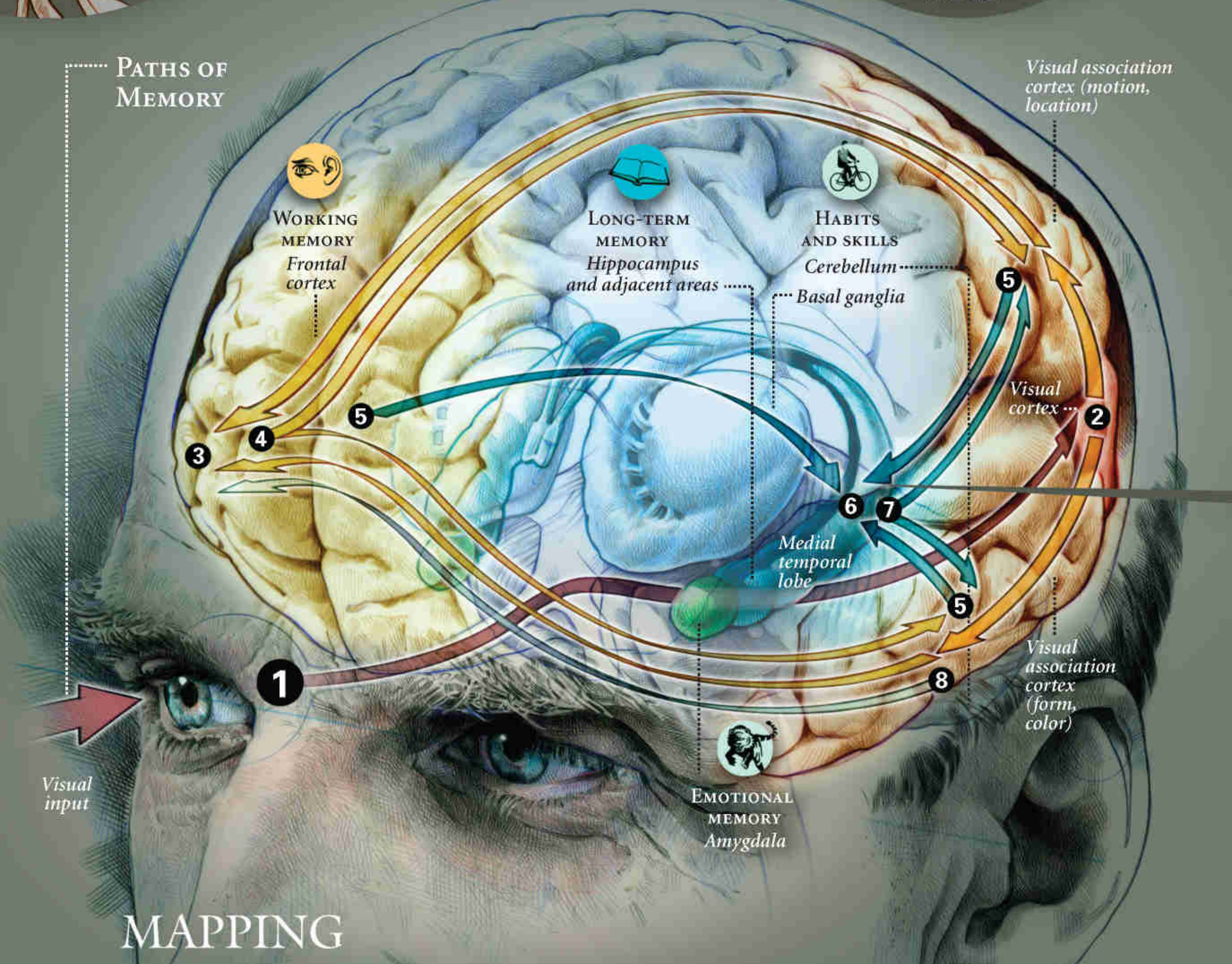

## Neurons

A memory is a stored pattern of connections formed by the brain's neurons, or nerve cells. A chemical neurotransmitter released by one neuron signals another. Each point of connection is called a synapse, and the average adult brain holds trillions (right).

## Memory capacity




## Paths of Memory




# MAPPING MEMORY

As your eyes scan these pages, billions of neurons are firing along the pathways of memory, retrieving what you know ("that's a brain") and responding to the new or the vaguely familiar ("the hippocampus?"). What you'll remember relies on many brain parts working together.

# The Process of Memory

## Receiving

ENCODING

### SHORT-TERM MEMORY

**Immediate**

❶ Sensory input is received in specialized parts of the cortex ❷ and held for fractions of a second.

**Working memory**

❸ The frontal cortex gets that information and keeps it available for immediate use (if asked what you're reading about, you'd say "memory") and coordinates its use by other parts of the cortex. ❹

### LONG-TERM MEMORY

**Memory for facts and events**

❺ After a few seconds, relevant facts begin to be encoded with the help of the hippocampus and other areas of the medial temporal lobes.

MILLISECONDS ▸▸▸▸▸ SECONDS ▸▸▸▸▸▸▸▸▸▸▸▸▸ SECONDS... THEN HOURS TO A LIFETIME

STORING

## Encoding

❻ Actions in the hippocampus and adjacent areas turn short-term memory into long-term. The neural connections that form as the cortex is stimulated by information are strengthened and linked to the emotional context in which they formed. Your hippocampus will help you remember this: Hippocampus is Greek for "seahorse." The part was named for its curved shape.


**Memory for habits/skills**

Habits and motor skills such as riding a bicycle are unconscious. Those memories rely on the basal ganglia and the cerebellum.

**Emotional memory**

The amygdala is the hub of neural connections created by emotional events, notably fear. It allows quick action in life-threatening situations.

RETRIEVING ▲▼ FORGETTING

## Storing and retrieving

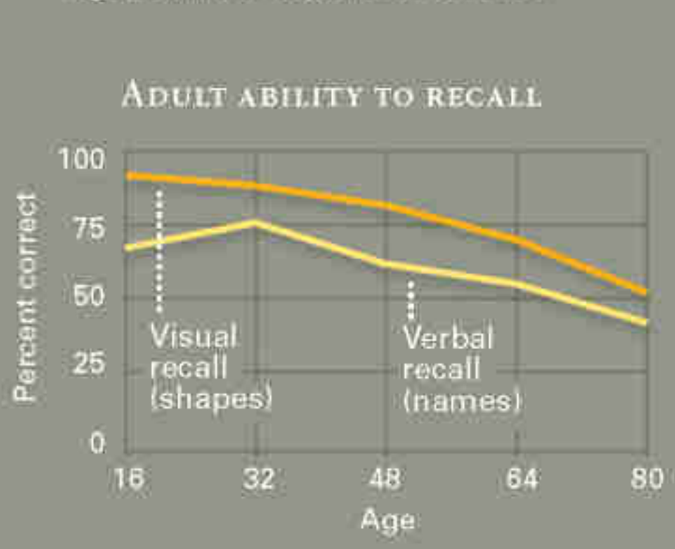
The hippocampus binds memories but does not store them. Once encoded, a memory resides in the region of the cortex in which the information was first perceived ❼ and processed. When needed, or elicited by emotion, the memory is activated to be used as working memory. ❽

## Forgetting

Most people have no memory of experiences before the age of three or four, a phenomenon called childhood amnesia, perhaps because the brain is not yet fully developed. As we age, our memory declines gradually, especially the ability to recall (rather than recognize) something seen or learned before.

CHILDHOOD AMNESIA


ADULT ABILITY TO RECALL




SOURCES: JOHN D. E. GABRIELI, DEPARTMENT OF BRAIN AND COGNITIVE SCIENCES, MIT; ALEX MARTIN, LABORATORY OF BRAIN AND COGNITION, NATIONAL INSTITUTE OF MENTAL HEALTH; LARRY R. SQUIRE, SAN DIEGO VETERAN AFFAIRS MEDICAL CENTER AND UNIVERSITY OF CALIFORNIA, SAN DIEGO; LARRY R. SQUIRE AND ERIC R. KANDEL, *MEMORY: FROM MIND TO MOLECULES*. ART BY BRUCE MORSER; CHARTS: K. SHEINGOLD AND Y. J. TENNEY, 1982 (TOP); A. D. BADDELEY, H. EMSLIE, AND I. NIMMO-SMITH, 1995 (BOTTOM); REPORTING AND DESIGN BY JUAN VELASCO, NGM ART

THOSE THREE POUNDS OR SO OF WRINKLED FLESH BALANCED ATOP OUR spines can retain the most trivial details about childhood experiences for a lifetime but often can't hold on to even the most important telephone number for just two minutes. Memory is strange like that.

neocortex, habit learning at the brain's center. As EP and HM so strikingly demonstrate, you can damage one part of the brain, and the rest will keep on working.

The metaphors we most often use to describe memory—the photograph, the tape recorder, the mirror, the hard drive—all suggest mechanical accuracy, as if the mind were some sort of meticulous transcriber of our experiences. And for a long time it was a commonly held view that our brains function as perfect recorders—that a lifetime of memories are socked away somewhere in the cerebral attic, and if they can't be found it isn't because they've disappeared, but only because we've lost access to them.

A Canadian neurosurgeon named Wilder Penfield thought he'd proved that theory by the 1940s. Penfield used electrical probes to stimulate the brains of epileptic patients while they were lying conscious on the operating table. He was trying to pinpoint the source of their epilepsy, but he found that when his probe touched certain parts of the temporal lobe, the patients started describing vivid experiences. When he touched the same spot again, he often elicited the same descriptions. Penfield came to believe that the brain records everything to which it pays any degree of conscious attention, and that this recording is permanent.

Most scientists now agree that the strange recollections triggered by Penfield were closer to fantasies or hallucinations than to memories, but the sudden reappearance of long-lost episodes from one's past is an experience surely familiar to everyone. Still, as a recorder, the brain does a notoriously wretched job. Tragedies and humiliations seem to be etched most sharply, often with the most unbearable exactitude, while those memories we think we really need—the name of the acquaintance, the time of the appointment, the location of the car keys—have a habit of evaporating.

Michael Anderson, a memory researcher at the University of Oregon in Eugene, has tried to estimate the cost of all that evaporation. According to a decade's worth of "forgetting diaries" kept by his undergraduate students (the amount of time it takes to find the car keys, for example), Anderson calculates that people squander more than a month of every year just compensating for things they've forgotten.

AJ remembers when she first realized that her memory was not the same as everyone else's. She was in the seventh grade, studying for finals. "I was not happy because I hated school," she says. Her mother was helping her with her homework, but her mind had wandered elsewhere. "I started thinking about the year before, when I was in sixth grade and how I loved sixth grade. But then I started realizing that I was remembering the exact date, exactly what I was doing a year ago that day." At first she didn't think much of it. But a few weeks later, playing with a friend, she remembered that they had also spent the day together precisely one year earlier.

"Each year has a certain feeling, and then each time of year has a certain feeling. The spring of 1981 feels completely different from the winter of 1981," she says. Dates for AJ are like the petite madeleine that sent Marcel Proust's mind hurtling back in time in *Remembrance of Things Past.* Their mere mention starts her reminiscing

A disease-free brain (top) shows intact temporal lobes along its lower flanks and, in the center, slender ventricles filled in life with cerebrospinal fluid. In a brain battered by Alzheimer's disease, the temporal lobes—a seat of memory and language—have been ravaged, and ventricles gape into voids left by cell death.

involuntarily. "You know when you smell something, it brings you back? I'm like ten levels deeper and more intense than that.

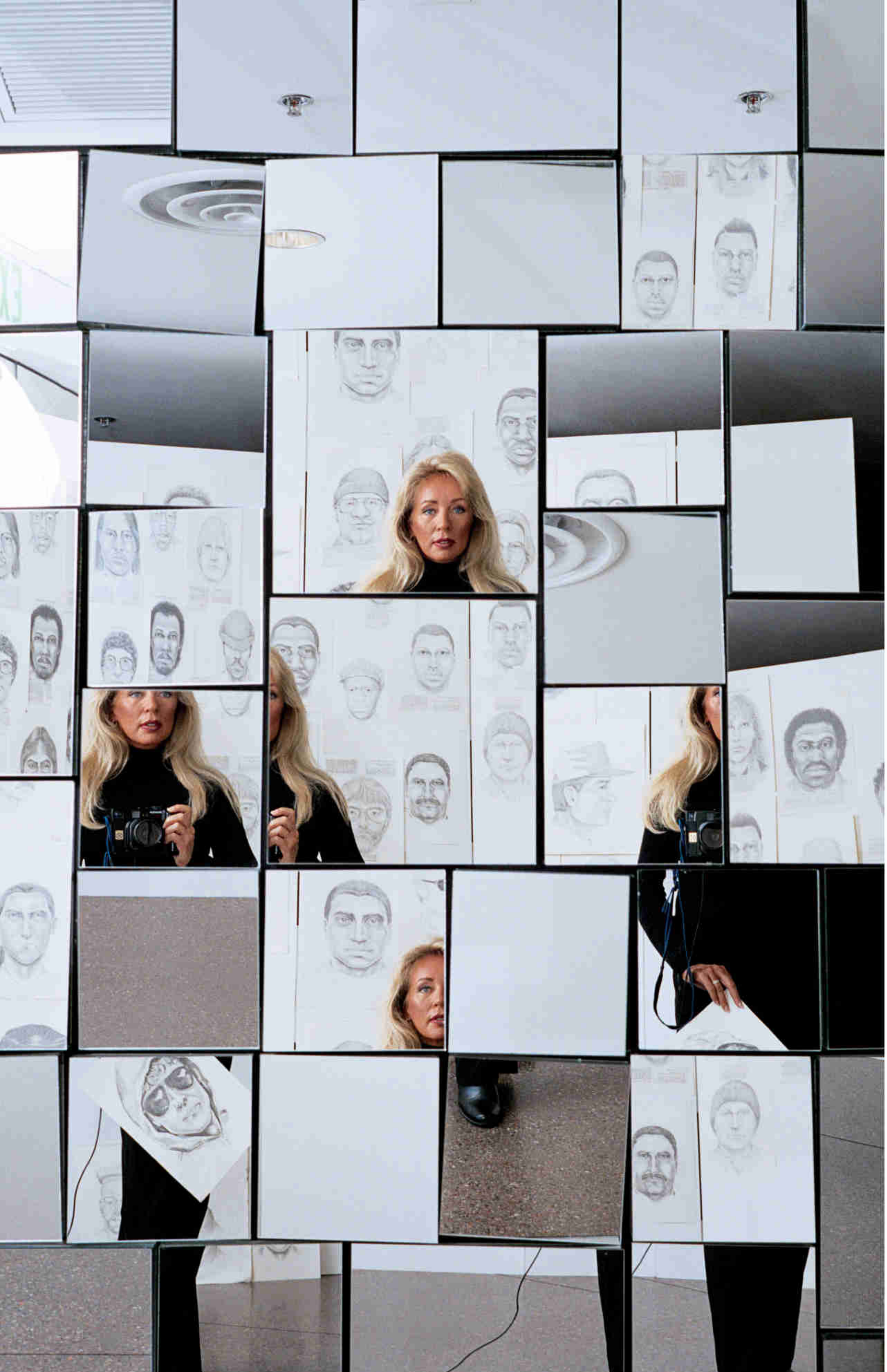
"My brother used to say, 'Oh, she's the Rain Man.' And I was like, 'No I'm not!' But I thought, what if I really. . . . Am I? Is there something wrong with me?" At one point AJ considered setting up shop on the nearby boardwalk as the Human Calendar and charging people five bucks to let them try to stump her with dates. She decided against it. "I don't want to be a sideshow."

It would seem as though having a memory like AJ's would make life qualitatively different—and better. Our culture inundates us with new information, yet so little of it is captured and cataloged in a way that it can be retrieved later. What would it mean to have all that otherwise lost knowledge at our fingertips? Would it make us more persuasive, more confident? Would it make us, in some fundamental sense, smarter? To the extent that experience is the sum of our memories and wisdom the sum of experience, having a better memory would mean knowing not only more about the world, but also more about oneself. How many worthwhile ideas have gone unthought and connections unmade because of our memory's shortcomings?

The dream that AJ embodies, the perfection of memory, has been with us since at least the

SPECIMENS COURTESY DAVID GEFFEN SCHOOL OF MEDICINE, UCLA

In the chirps and twitters of pocket-size birds, Fernando Nottebohm heard the anthem of a brain-science revolution. The Rockefeller University biologist discovered that adult canaries do something a century of neuroscience dogma declared impossible: They generate new neurons to replace lost brain cells. Replacement peaks during peak memory load—when birds learn new songs, find new food sources, or meet new social partners. Other researchers have extended Nottebohm's findings, confirming that mammals, including humans, also make new neurons. "With luck and much effort," Nottebohm says, "the simple insight I got from studying how birds learn their songs will help us find the means to repair broken brains."



fifth century B.C. and the supposed invention of a technique known as the "art of memory" by the Greek poet Simonides of Ceos.

Simonides had been the sole survivor of a catastrophic roof collapse at a banquet hall in Thessaly. According to Cicero, who wrote an account of the incident four centuries later, the bodies were mangled beyond recognition. But Simonides was able to close his eyes to the chaos and see in his mind each of the guests at his seat around the table. He'd discovered the loci method. If you can convert whatever it is you're trying to remember into vivid mental images and then arrange them in some sort of imagined architectural space, known as a memory palace, memories can be made virtually indelible.

Peter of Ravenna, a noted Italian jurist and author of a renowned memory textbook of the 15th century, was said to have used the loci method to memorize the Bible, the entire legal canon, 200 of Cicero's speeches, and 1,000 verses of Ovid. For leisure, he would reread books cached away in his memory palaces. "When I left my country to visit as a pilgrim the cities of Italy, I can truly say I carry everything I own with me," he wrote.

It's hard for us to imagine what it must have been like to live in a culture before the advent of printed books or before you could carry around a ballpoint pen and paper to jot notes. "In a world of few books, and those mostly in communal libraries, one's education had to be remembered, for one could never depend on having continuing access to specific material," writes Mary

**OVER THE PAST MILLENNIUM, MANY OF US HAVE UNDERGONE A PROFOUND SHIFT.**
We've gradually replaced our internal memory with a vast superstructure of technological crutches that we've invented so that we don't have to store information in our brains.

Carruthers, author of *The Book of Memory,* a study of the role of memory techniques in medieval culture. "Ancient and medieval people reserved their awe for memory. Their greatest geniuses they describe as people of superior memories." Thirteenth-century theologian Thomas Aquinas, for example, was celebrated for composing his *Summa Theologica* entirely in his head and dictating it from memory with no more than a few notes. Roman philosopher Seneca the Elder could repeat 2,000 names in the order they'd been given to him. Another Roman named Simplicius could recite Virgil by heart —backward. A strong memory was seen as the greatest of virtues since it represented the internalization of a universe of external knowledge. Indeed, a common theme in the lives of the saints was that they had extraordinary memories.

After Simonides' discovery, the art of memory was codified with an extensive set of rules and instructions by the likes of Cicero and Quintilian and in countless medieval memory treatises. Students were taught not only what to remember but also techniques for how to remember it. In fact, there are long traditions of memory training in many cultures. The Jewish Talmud,

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Jeanne Boylan recovers fragmented impressions of shapes and textures etched deep in memory by trauma. The veteran forensic artist, who has helped solve some of the most notorious crimes of the past 30 years, says her crucial skill is not drawing, but simply listening—often for hours. "Witnesses surprise themselves," she says, "with what they remember."

Memorizing sequences of playing cards, a classic mental exercise, helps Raemon Matthews's students at Samuel Gompers High School in New York's South Bronx hone their skills for tougher academic challenges. Almost a fourth of the competitors in this year's USA Memory Championships were Matthews's pupils.

embedded with mnemonics—techniques for preserving memories—was passed down orally for centuries. Koranic memorization is still considered a supreme achievement among devout Muslims. Traditional West African griots and South Slavic bards recount colossal epics entirely from memory.

But over the past millennium, many of us have undergone a profound shift. We've gradually replaced our internal memory with what psychologists refer to as external memory, a vast superstructure of technological crutches that we've invented so that we don't have to store information in our brains. We've gone, you might say, from remembering everything to remembering awfully little. We have photographs to record our experiences, calendars to keep track of our schedules, books (and now the Internet) to store our collective knowledge, and Post-it notes for our scribbles. What have the implications of this outsourcing of memory been for ourselves and for our society? Has something been lost?

To supplement the memories in her mind, AJ also stores a trove of external memories. In addition to the detailed diary she's kept since childhood, she has a library of close to a thousand videotapes copied off TV, a trunk full of radio recordings, and a "research library" consisting of 50 notebooks

filled with facts she's found on the Internet that relate to events in her memory. "I just want to keep it all," she says.

Preserving her past has become the central compulsion of AJ's life. "When I'm blow-drying my hair in the morning, I'll think of whatever day it is. And to pass the time, I'll just run through that day in my head over the last 20-something years—like flipping through a Rolodex."

AJ traces the origins of her unusual memory to a move from New Jersey to California that her family made when she was just eight years old. Life in New Jersey had been comfortable and familiar, and California was foreign and strange. It was the first time she understood that growing up and moving on necessarily meant forgetting and leaving behind. "Because I hate change so much, after that it was like I wanted to be able to capture everything. Because I know, eventually, nothing will ever be the same," she says.

K. Anders Ericsson, a professor of psychology at Florida State University, believes that at bottom, AJ might not be all that different from the rest of us. After the initial announcement of AJ's condition in the journal *Neurocase*, Ericsson suggested that what needs to be explained about AJ is not some extraordinary, unprecedented innate memory but rather her extraordinary obsession with her past. People always remember things that are important to them. Baseball fanatics have an encyclopedic knowledge for statistics, chess masters remember tricky gambits that took place years ago, actors remember scripts long after performing them. Everyone has got a memory for something. Ericsson believes that if anyone cared about holding on to the past as much as AJ does, the feat of memorizing one's life would be well within reach.

I mention Ericsson's theory to AJ, and she becomes visibly upset. "I just want to call him on the phone and yell at him. If I spent that much time memorizing my life, then I really would be a boring person," she says. "I don't sit around and memorize it. I just know it."

**THE DREAM THAT SHE EMBODIES, THE PERFECTION OF MEMORY, has been with us since at least the fifth century B.C. and the invention of a technique known as the "art of memory" by the Greek poet Simonides of Ceos.**

Remembering everything is both maddening and lonely for AJ. "I remember good, which is very comforting. But I also remember bad—and every bad choice," she says. "And I really don't give myself a break. There are all these forks in the road, moments you have to make a choice, and then it's ten years later, and I'm still beating myself up over them. I don't forgive myself for a lot of things. Your memory is the way it is to protect you. I feel like it just hasn't protected me. I would love just for five minutes to be a simple person and not have all this stuff in my head. Most people have called what I have a gift," AJ says, "but I call it a burden."

The whole point of our nervous system, from the sensory organs that feed information to the massive glob of neurons that interpret it, is to develop a sense of what is happening in the present and what is about to happen in the future, so that we can respond in the best possible way. Our brains are fundamentally prediction machines, and to work they have to find order in the chaos of possible memories. Most of the things that pass through our brains don't need to be remembered any longer than they need to be thought about.

Harvard psychologist Daniel Schacter has developed a taxonomy of forgetting to catalog what he calls the seven sins of memory. The sin of absentmindedness: Yo-Yo Ma forgetting his

In winter sunlight, Sister Loretta Semposki meditates. An avid reader, the 94-year-old scores very high on annual memory tests conducted by the University of Kentucky's Nun Study. She's one of 678 Roman Catholic School Sisters of Notre Dame, all born before 1917, who have volunteered their life histories—and their brains, after they die—to this long-term study of healthy aging and mental decline. The archive of test data and tissue samples assembled over nearly 20 years is helping scientists figure out why some people's memories dim and others—like Sister Loretta's—remain crystal bright for a lifetime.

HIS WIFE,
BEVERLY, NOW
LETS HIM GO
OUT ALONE,
even though a wrong
turn would leave him
completely lost. Sometimes
he comes back with objects
he's picked up along
the way: a stack of round
stones, a puppy,
somebody's wallet.

2.5-million-dollar cello in the back of a taxi. The Vietnam War veteran still haunted by the battlefield suffers from the sin of persistence. The politician who loses a word on the tip of his tongue during a stump speech is experiencing the sin of blocking. Though we curse these failures of memory on an almost daily basis, Schacter says, that's only because we don't see their benefits. Each sin is really the flip side of a virtue, "a price we pay for processes and functions that serve us well in many respects." There are good evolutionary reasons why our memories fail us in the specific ways they do. If everything we looked at, smelled, heard, or thought about was immediately filed away in the enormous database that is our long-term memory, we'd be drowning in irrelevant information.

In his short story "Funes the Memorious," Jorge Luis Borges describes a man crippled by an inability to forget. He remembers every detail of his life, but he can't distinguish between the trivial and the important. He can't prioritize, he can't generalize. He is "virtually incapable of general, platonic ideas." Perhaps, as Borges concludes in his story, it is forgetting, not remembering, that is the essence of what makes us human. "To think," Borges writes, "is to forget."

To age is to forget, also. Roughly five million Americans have Alzheimer's disease, and even more suffer from mild cognitive impairment, or lesser degrees of memory loss. When asked to recall a list of 15 words read 20 minutes earlier, octogenarians in one study recalled fewer than 60 percent, while the twenty-somethings could remember close to 90 percent.

Not surprisingly, people have been searching a long time for chemicals that might halt that tide of forgetting. According to Franciscan Bernardo de Lavinheta, writing in the early 1500s, "Artificial memory is twofold: the first part consists in medicines and poultices." The second part, of course, is the art of memory, which Lavinheta deemed both safer and more effective (since memory medicines can sometimes have the unfortunate side effect of "drying up the brain"). Today ginkgo biloba is sold as an over-the-counter supplement, or added to fruit smoothies and "smart" soft drinks, even without conclusive evidence that it either boosts memory—or dries up the brain.

Within the past decades, drug companies have elevated the search to brave new heights. Armed with a sophisticated understanding of memory's molecular underpinnings, they've sought to create new drugs that amplify the brain's natural capacity to remember. In recent years, at least three companies have been formed with the express purpose of developing memory drugs. One of those companies, Cortex Pharmaceuticals, is attempting to develop a class of molecules known as ampakines, which facilitate the transmission of the neurotransmitter glutamate. Glutamate is one of the primary excitatory chemicals passed across the synapses between neurons. By amplifying its effects, Cortex hopes to improve the brain's underlying ability to form and retrieve memories. When administered to middle-age rats, one ampakine was able to fully reverse their age-related decline in the cellular mechanism of memory.

It may not be long before drugs such as ampakines begin to reach the market; when they do, they could have an enormous impact on society. Though the pharmaceutical companies

are searching for therapeutic treatments to stave off Alzheimer's and combat dementia, it seems inevitable that their pills will end up in the hands of students cramming for exams and probably a whole lot of other people who just want to enhance their brains. Already psychostimulants designed to treat ADHD, like Adderall and Ritalin, are used as "study buddies" by as many as one in four students at some colleges trying to increase their concentration and improve their memories.

All of this raises some troubling ethical questions. Would we choose to live in a society where people have vastly better memories? In fact, what would it even mean to have a better memory? Would it mean remembering things only exactly as they happened, free from the revisions and exaggerations that our mind naturally creates? Would it mean having a memory that forgets traumas? Would it mean having a memory that remembers only those things we want it to remember? Would it mean becoming AJ?

I want to see EP's unconscious, nondeclarative memory at work, so I ask him if he's interested in taking me on a walk around his neighborhood. He says, "not really," so I wait and ask him again a couple minutes later. This time he agrees. We walk out the front door into the high afternoon sun and turn right. I ask EP why we're not turning to the left instead.

"I'd just rather not go that way. This is just the way I go. I don't know why," he says.

If I asked him to draw a map of the route he takes at least three times a day, he'd never be able to do it. He doesn't even know his own address, or (almost as improbably for someone from San Diego) which way the ocean is. But after so many years of taking the same walk, the journey has etched itself on his unconscious. His wife, Beverly, now lets him go out alone, even though a single wrong turn would leave him completely lost. Sometimes he comes back from his walks with objects he's picked up along the way: a stack of round stones, a puppy, somebody's wallet. He's never able to explain how they came into his possession.

"Our neighbors love him because he'll come up to them and just start talking to them," Beverly says. Even though he thinks he's meeting them for the first time, he's learned through habit that these are people he should feel comfortable around, and he interprets those unconscious feelings of comfort as a good reason to stop and say hello.

We cross the street and I'm alone with EP for the first time. He doesn't know who I am or what I'm doing at his side, although he seems to sense that I'm there for some good reason. He is trapped in the ultimate existential nightmare, blind to the reality in which he lives. The impulse strikes me to help him escape, at least for a second. I want to take him by the arm and shake him. "You have a rare and debilitating memory disorder," I want to tell him. "The last 50 years have been lost to you. In less than a minute, you're going to forget that this conversation ever even happened." I imagine the sheer horror that would befall him, the momentary clarity, the gaping emptiness that would open up in front of him, and close just as quickly. And then the passing car or the singing bird that would snap him back into his oblivious bubble.

We turn around and walk back down the street whose name he's forgotten, past the waving neighbors he doesn't recognize, to a home he doesn't know. In front of the house, there is a car parked with tinted windows. We turn to look at our reflections. I ask EP what he sees.

"An old man," he says. "That's all."

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**Mind Games** Turn the human brain upside down and all around to see how memories are saved (or lost) at **ngm.com**.

# WHEN MEMORY ENDS

BY MAGGIE STEBER

My mother, Madje Steber, is experiencing the melancholic voyage of memory loss. She is at sea. As her only child, I have booked passage on another ship myself, to sail across the lifetime of memories that once described her life.

I photograph my mother to help me get through this voyage, creating new memories for myself along the way. I show her the photos, even if she does not recognize herself. For her, they are postcards from distant lands. How can she be so achingly beautiful now, even though her brow is knit with confusion? She disappears from my view before my very eyes. With each day she nears the horizon she will reach alone, leaving me with only memories, precious memories, of her long, last journey. □

# While the King Sleeps

## Democracy stirs in Tonga, the Pacific's last true monarchy.

*Longo Moala gathers pandanus leaves that have been soaked in seawater. Once they dry, she will weave them into mats—carrying on a Tongan tradition.*

*Leaning on each other is a team-building exercise and an ethic for new enlistees with the Tonga Defence Services. After a massive riot in 2006, the TDS plans to expand its 450-person land and naval forces.*

By Matthew Teague
Photographs by Amy Toensing

*The morning rush hour is no rush at all in the village of Ta'anea—and in much of Tonga. Roughly half the nation's 200,000 citizens live overseas, mostly in the United States, Australia, and New Zealand, where they work to help support folks back home: Three-quarters of all Tongan households receive remittances from family and friends living elsewhere.*

THE ROYAL GUARDS slouched a little, and wore pith helmets. They stood looking at their feet, so that their faces disappeared behind the helmet brims. One guard swept a boot across the gravel, as though an explanation might lie hidden underneath.

"I'm sorry," he said. "It could be a while."

The Crown Prince of Tonga had sent word earlier that morning that he would grant me an audience. Now the sun stood high overhead, and we all sweated in the royal driveway, clearing our throats and crunching the gravel underfoot.

The prince's mansion sat on a high hill overlooking much of the kingdom. It's the last true monarchy in the Pacific, and one of the last in the world. A few weeks earlier in the summer, the beloved and ancient king had checked into a hospital in New Zealand. Now his unloved son, the prince, prepared to ascend the throne.

Prince Tupouto'a could live at the royal palace by the sea, but he prefers the sprawling hilltop redoubt. Tongans call it "the villa," when they speak of it. It's a neoclassical affair, with marble columns and a pool where he sometimes plays with toy boats. On this particular day the guards washed the crown prince's cars: a jaunty Jaguar, a sport-utility vehicle, and a London black taxicab. His Royal Highness had seen the taxi in England, a guard explained, and decided to ship one back home. No one seemed to know why, and I promised to ask the prince.

From the villa a great white driveway descended the hill, sweeping past a fountain and a guardhouse. There it joined the road into Tonga's capital, a hot and dusty town called Nuku'alofa, home to a third of the country's 100,000 inhabitants. At the base of the hill, on the road to town, a woman sat making brooms from palm fronds, hoping to trade them later on in this largely barter economy. Farther toward town, a little yellow food stand bore the slogan "Democracy, not Hypocrisy." Farther still, the royal tombs stood vast and ageless, where workers prepared for the king's imminent death. Farthest of all, beyond the prince's hilltop view, squatters lived at the island's garbage dump, scrounging for anything salvageable.

There's a movement afoot among Tongan commoners. While the Western world struggles to plant democracy other places around the globe, in Tonga it's sprouting from the soil. Its growth has been nurtured by the forces of modernity, which have crashed into Tonga in a relative instant: the ease of air travel and the improvement of technology. Geographic distance no longer means ideological isolation.

So the country now finds itself at a moment of decision: stuck midway between the past and


future, monarchy and democracy, isolation and global engagement.

The apologetic, pith-helmeted guard trotted away, and returned a few minutes later. "I'm sorry," he said again. "His Royal Highness is asleep. Everyone is afraid to wake him."

TONGAN ROYALS deserve a measure of fear. Starting about 900 years ago, a long lineage of kings used war and diplomacy to spread Tonga's influence to other gentler island neighbors, including Samoa and perhaps Fiji. Even today Tonga remains the only country in the Pacific never to be governed by a foreign power.

The country's history is one of relative isolation, and Tongans are among the most ethnically homogeneous people on the planet. But the culture has been buffeted by waves from afar—explorers, missionaries, swindlers, and suitors all leaving their mark. Captain James Cook arrived in the 1770s, and impressed by the hospitality of the locals (and unaware of their plans to try to kill him), dubbed it the Friendly Isles, a nickname that stuck. When swimming, many Tongans wear clothes, often black, instead of swimsuits, modesty that reflects the nation's large and conservative Methodist and Mormon populations. Tonga has a literacy rate of 99 percent and claims to produce more Ph.D.'s per capita than other nations in the region, but the

country's largest source of income is money sent home by Tongans who have moved overseas. And Tonga has a 32-seat parliament, but only nine members are elected by the people. The others are selected by the king and the nobles, and all decisions are subject to the king's approval.

The king during my visit, Tupou IV, enjoyed respect from his people for decades. He even looked royal from a distance—six feet two inches tall and weighing up to 460 pounds. When he was younger, he surfed and dived, and the islanders adored him. But in recent years, as the king's health failed and his attention wandered, the royal family stumbled into a series of schemes that can only be described as wacky.

The king, for instance, committed millions of dollars trying to convert seawater to natural gas. His oldest son, the crown prince, proposed making their islands a nuclear waste disposal site. The monarchy led an expensive search for oil, despite slim geologic evidence there was any oil to find. They registered foreign ships with giddy abandon, including some that turned out to be, embarrassingly, part of al Qaeda's fleet. The list goes on.

But the plot that really angered the kingdom's subjects started in the 1980s, when the king hit on the idea of selling Tongan passports. The world's most unwanted citizens—and sometimes "wanted"—jumped at the opportunity. Imelda Marcos, for instance, became a Tongan

*Leaving his niece's wedding reception, newly installed King George V keeps his dog, Pip, on a tight leash. As the South Pacific's only ruling monarch, the king is struggling to keep control amid demands for democratic reform by activists, some of whom have been put on trial for sedition. To quell the unrest, the king has endorsed certain political reforms, but only those he deems to be "appropriate for Tonga."*

citizen. The sale ultimately rang up 25 million dollars before protests ended it. But that's when the deal took its weirdest turn: The king turned over the money to an American schemer named Jesse Bogdonoff, whose previous business dealings included selling magnetic bracelets. The king appointed him official court jester. He was the only one in the world, and a royal decree pronounced him "King of Jesters and Jester to the King, to fulfill his royal duty sharing mirthful wisdom and joy as a special goodwill ambassador to the world."

His first turn as jester was a vanishing act: He invested the kingdom's money in an insurance scheme and lost it all, then disappeared. The Tongan people, feeling less than mirthful, started to question the role of the royal family. The monarchy seemed increasingly out of touch. The crown prince, for instance, had spent much of his upbringing abroad, educated at Sandhurst and Oxford. He wore impeccably tailored tweed suits and sometimes a monocle. He spoke with a precise British accent, and liked to collect toy soldiers. In 1998 he quit a cabinet position to pursue business interests, and soon he owned the brewery, electric company, a telecommunications company, airline, and more. Watching it all, his people were incredulous, but the prince didn't seem to care. He told newspapers that without royal guidance, Tongans would "urinate in elevators." He dismissed Tongan livelihoods, such as "basket weaving or whatever it is these people do." Increasingly, many Tongans wondered whether the prince hated them. Or more to the point, whether they hated the prince.

In the 1980s a young man named ʻAkilisi Pohiva emerged as a voice of dissent. He stood in public and railed against the monarchy. Other Tongans laughed at him. He thought differently than they did, and even looked different: Among round people with round features, Pohiva looked like a hawk, with eyes that gazed down either side of a sharp nose. He was jailed twice for speaking against the government.

But after years of royal goofs, Pohiva's calls for political reform have slowly taken hold, culminating in open unrest in 2005. It started as a strike by the country's civil employees, who wanted pay increases. But the protest grew into a full-on demand for democracy. Rioters overturned cars, marched the streets, firebombed a royal residence, and—unthinkably, in Tongan culture—threatened bloodshed.

AFTER MY FIRST ATTEMPT to meet the crown prince, his secretary told me it might be a while before he would see me. So while I waited, I set out to see the kingdom.

At the airport outside the capital city, a languorous clerk checked bags for island-hopping flights by Peau Vavaʻu, the crown prince's airline. "Please place your luggage on the scale," she

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*Matthew Teague, a staff writer for* Philadelphia *magazine, has contributed to national publications, including* The Atlantic *and* GQ. *Photographer Amy Toensing shoots regularly for* National Geographic.

*Sunday unfolds slowly as the Sauati family preps a big meal that will simmer in an underground oven while everyone goes to church. In this mostly Christian country, a Sabbath day of rest is the law of the land.*

said, noting the weight with a pencil. It brought strange comfort, in an age of plastic explosives and sniffer dogs, that somewhere in the world an airline still depends on longhand arithmetic.

"And now you," she said.

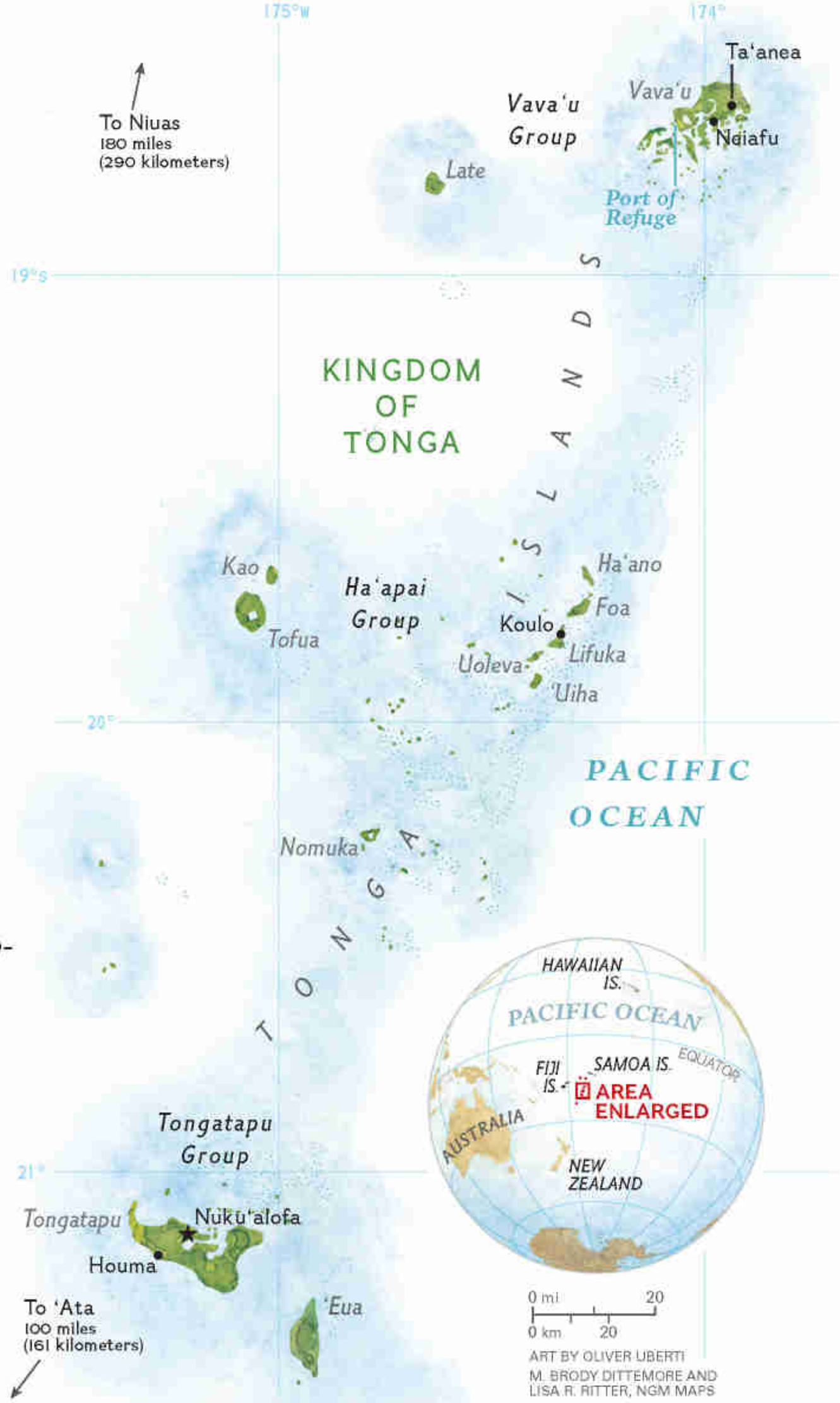
"Yes?"

"Please step on the scale."

The prince's plane, she explained, was "not new," and so it was crucial that she total all cargo, from luggage to passengers to pigs. Out on the tarmac I saw just how "not new" the prince's airplane was: There sat a gleaming Douglas DC-3, left over from the Second World War. Dwight Eisenhower flew in one when he was just a general, and these days they're rarely seen outside museums, much less flown in daily commercial use. But the prince loves them. After a white-gloved attendant waved the passengers aboard, the ancient Pratt & Whitney radial motors sputtered awake and strained to heave us skyward, riding up and down the waves of wind like a ship on water. I realized, as ukulele music floated through the cabin, that we were flying aboard the prince's favorite toy airplane.

From high above, Tonga looked like green flecks against a blue background. Its islands are tiny and far-flung: 500 miles from one end to the other, and almost all water. The islands fall into three main groups—Vava'u, Ha'apai, and Tongatapu—each so different that to the visitor

*A scrim of seawater rises from blowholes along the coast of Tongatapu—one of 36 inhabited islands in the 170-island archipelago that is Tonga. First settled more than 3,000 years ago, this chain became the anchor for a not-so-pacific domain that by the 13th century may have stretched as far as Samoa and Fiji. In the 1600s, European explorers arrived, followed by missionaries. But now the pressure for change rises from within.*




they lack any meaningful connection. Traveling between them feels less like a geographic journey than a chronological one; each island group seems to exist within a different point in the country's history.

My first destination was the Vava'u Group: Tonga of the future.

**YES, YES, THE BOAT CAPTAIN SAID.** We've got a couple of sharks off the bow, but they're only "little ones." Which would have sounded a good deal more reassuring if we hadn't just pushed several tourists off the stern.

The sharks disappeared underwater, and the captain, a New Zealander named Allan Bowe, grinned. "They'll be fine," he said, laughing. Bowe is a whale hunter, of a peculiar sort. His long gray beard whipped in the wind, and sunlight got lost in the wrinkles around his eyes. Meanwhile the tourists bobbed in the deep water like chum.

Humpback whales migrate north each year from cold Antarctic waters and spend five months among the islands. Big and strong, the whales look like they could swallow a dugout canoe without a burp. Bowe, though, saw an opportunity. On a boating trip to Vava'u about 15 years ago, he took a leap, diving into the water to splash around with the whales. "It scared me witless at first," he said. But the humpbacks

The crown prince dismissed Tongan livelihoods, such as "basket weaving or whatever it is these people do."

*Kalisi Paonga has died. At her funeral, her highest ranking relative—the eldest paternal aunt—sits close by in a chair as mourners file past. Across Tonga, traditional hierarchies are still very much alive.*

just nosed around like enormous underwater basset hounds, and in an instant Bowe conceived a new industry: swimming with whales.

Vava'u draws in dreamers and sailors from around the world; tourists park their yachts in the Port of Refuge and come ashore to sip coffee at The Mermaid. Yachts sail in easily from New Zealand or Hawaii, but to leave they've got to sail far east or west to catch homeward trade winds. So, often they simply never leave. Some yacht sailors have stayed anchored off Vava'u for years, or even lifetimes.

After Allan Bowe's epiphany about swimming with whales, he bought a boat, outfitted it for the business, and sparked a debate among conservationists and thrill seekers. Scientists haven't agreed on the impact of swimming with whales. Some people say it disturbs them and their environment, while others argue anything that brings attention to the whales helps save them from hunting.

On Bowe's boat, batch after batch of tourists plunked into the water and survived despite the sharks. Again and again they climbed back into the boat with tales of a mystical experience. They had communed with nature, they said, and felt the wonder of the moment. So I pulled on a pair of flippers and hopped off the stern along with three other swimmers. We paddled toward a pair of humpbacks, a mother and baby, and almost

immediately they turned away. With one mighty swoosh they were gone.

We saw grace there, and beauty and awe, but overwhelmingly I sensed something else. I felt like a man walking on an empty beach, who happens across a couple reclining together on a towel, and suddenly decides to plop down beside them.

The whales seemed, more than anything, annoyed.

THE PRINCE'S ANTIQUE AIRPLANE rattled into tiny Lifuka, the main island of the Haʻapai Group, and parked at the one-room airport. As soon as the pilot cut the engines, a deep silence saturated the island. After the touristy bustle of Vavaʻu, Haʻapai felt like a patch of some other era: Tonga of the past.

A lone car sat outside the airport, with a barefoot man standing beside it, grinning. "Ride?" The island is only a few miles square, and the driver crossed it at little more than a walking pace. This happens all over Tonga, where cars only caught on in recent years, and people drive them as if they were horses. But in Haʻapai cars barely outnumber horses. The island group is flat, unspoiled, and quiet. The people live simple lives, fishing and farming. They care little for politics and have little exposure to tourism. Many live on Lifuka and keep animals on a nearby island, Uoleva. At low tide they can cross on horseback.

One day I met a young man named Roni who offered to let me come along for a pig feeding on Uoleva. We rode bareback with homemade rope bridles, and the outgoing tide washed over the flanks of the horses. They tripped across a coral seafloor, angling their bodies to lower their profile against the current. We emerged onto the Uoleva beach, and the horses surged from the water, so that we felt like the conquerors of some tiny and faraway new world.

At the grove where he keeps his pigs, Roni climbed a tree and knocked down some coconuts, which we cracked open and drank. He filled a water bowl for the animals and scattered some food. Then he ran and leaped at his horse, vaulting onto its back. Before we left, he trotted around a bit, awash in a sea of tranquillity.

The troubles on Tongatapu, the kingdom's main island—Tonga of the present—seemed centuries away.

AFTER SUNDOWN the village of Houma, like every other village on Tongatapu, goes well and truly dark. And on this particular night, dozens of villagers emerged from the blackness into a tin-roofed meeting hall to plot a democracy.

The room was lit only by a few weak fluorescent bulbs, with murals on the walls. The women sat on metal folding chairs with their hands folded in their laps. The men sat in an oval on the floor, around a great six-footed wooden bowl of kava. It's a gently narcotic drink, made from a local root and served in halved coconut shells. Tongan men drink it down to the bitter residue at the bottom of the shell, then fling the shell toward the big bowl for a refill. Kava tends to slow down time for its drinker, so such sessions often last all night.

The men at the democracy meeting invited me to sit and drink. I did, and worked to keep pace, but it didn't matter because the drink didn't seem to have any effect. Everyone just laughed and told jokes about the crown prince and his wealth, and we drank kava. Someone complained about taxes, and we drank kava. Then slowly the eyes of the men in the oval seemed to soften, and their smiles lingered long after each joke had faded. An old man danced in the corner to no music, and another old man with purple hair sat singing softly to himself. Someone gave Prince Tupoutoʻa the new name of Prince Tippytoes.

ʻAkilisi Pohiva strode into the room, and immediately stood out from his stoned compatriots. Time has not dulled the edges of his hawkish face, or his rhetoric. No one laughs at him now; he's one of the few members of parliament elected by the people, and the longest serving. As the men and women gathered around, he spoke. "Last year I was charged with sedition," he told the crowd. The penalty for speaking out, he said, "is indicative of their pressure. They are putting pressure on us."

Pohiva grew up on a tiny island in the Haʻapai Group. His parents died when he was a child, so his brothers raised him. There had been no school for boys previously in Haʻapai, and young Pohiva was one of the original 25 students at the first school. He did well, and later attended the University of the South Pacific in Fiji. He told me that's where he started to question the Tongan royal family, and learned about democracy. "At the university," he told me on another day, "I was

*Rising with the sun, uniformed students head for class at a public elementary school in Koulo. The state curriculum includes lessons about democracy, but the subject is taught as history, not civics.*

"I think we'll probably carry on doing things the way we have in the past, which has been very successful," said the future king.

*Files fill a back room at the prime minister's office, but out front computers are everywhere. New technology may improve government efficiency, but the changes democracy activists are seeking go deeper.*

exposed to the alternatives. The history of other countries, democracy, communism, socialism. That really helped widen my knowledge."

After several hours of speeches from the meeting attendees, thoughts blurred by kava had resharpened their edges. One of the democracy organizers set a document on a table at the front of the room. It was a petition to wrest power from the royal family by giving more seats in parliament to the people. The organizers didn't want to destroy the royal family, but to set it aside, after the British model.

One by one they stepped up to the desk, picked up the pen, and signed their names. And so among these strange surroundings, saturated in kava and singing old songs, the Tongans shaped democracy in their own image.

THE CROWN PRINCE, after some weeks, granted an audience.

The guard at the entrance to the property waved me in, and I climbed the hill toward the villa. I waited on the lawn while His Royal Highness finished a meeting with the ambassador from the Netherlands; the king of Tonga was ill in New Zealand and would die within a few weeks, so the crown prince was serving as the country's interim ruler. Scores of guards lounged in the sun with a variety of brass instruments. When the ambassador emerged, they snapped

to attention and played a march until she had climbed into her car and pulled away.

The crown prince's personal secretary brought me to the villa's front door. It opened onto a breezeway that separated the house's two wings. The day was warm, but the villa sat atop a hill, and a cool breeze swept in. The sound of the secretary's shoes echoed off marble floors and columns. The walls were mostly bare, but painted in the trompe l'oeil style to convey the illusion of depth.

The secretary left me alone in a sitting room that seemed to belong to three or four different people. Ancient religious icons lined the mantel of the fireplace, a collection of Japanese art filled one corner, abstract art hung elsewhere. A piano sat in another corner; the prince plays jazz, and once formed a band in England. The electric outlets were all of the American type, instead of the local current, because the prince prefers appliances bought in the U.S.

A few minutes later the prince entered the room. "Hello," he said, in a British accent as rich as plum pudding. He extended a hand, with a palm so soft it felt wet. He sat on an ottoman, unbuttoning the jacket of a gray tweed three-piece suit. A woman appeared. She crossed the room with what appeared at first to be an empty silver serving tray, but when she bent toward the prince, he picked up a cigarette.

We chatted for a while about his background and upbringing in England. I asked him about the taxi imported from London, and his desire for it. "Practicality, really," he said. "A London taxi is easier to get in and out of when you're wearing a sword."

There's another practicality: The cab features curtains in the windows, which the prince pulls shut as he rides around his country, so that his people can't see him, and he can't see them. I asked if things would change, once he ascended.

"I think we'll probably carry on doing things the way we have in the past, which has been very successful," said the future king.

A few days earlier I had visited Tonga's school for disabled children, where the computers were donated by Australia, and the vehicle was donated by the people of Japan. It seems unfair, I said, sweeping a hand toward the Japanese art and the view beyond, for the royals and the nobles to have what is relative opulence and wealth, while other, less fortunate people rely on foreign help. Is that an unfair criticism?

He dismissed it with a wave of his hand, noting that despite America's reputation for wealth and power, it also has poor people in inner cities and rural areas. "Lubbock, Texas," he said, "and such places."

His hand rose slowly, and he pulled a long breath from a new cigarette.

"Foreign aid is foreign aid," he said. "So how you treat other people's kindnesses is not their business, it's yours."

I pondered that statement for a bit, and decided I had been told off, in the royal way. The audience didn't last much longer. At the end I thanked the prince for his time, and for . . .

"Goodbye," he said. The sharp interruption stood in such contrast to the warm smile on his face that I didn't realize for several moments that I had been dismissed. The prince turned his back and walked away, leaving me alone.

I wandered back outside into the sunlight, where the prince's driver, Harry Moala, washed the royal vehicles. He saw me and smiled, and asked if I needed a ride back to town.

"Sure."

"How about in the Jaguar?" he said.

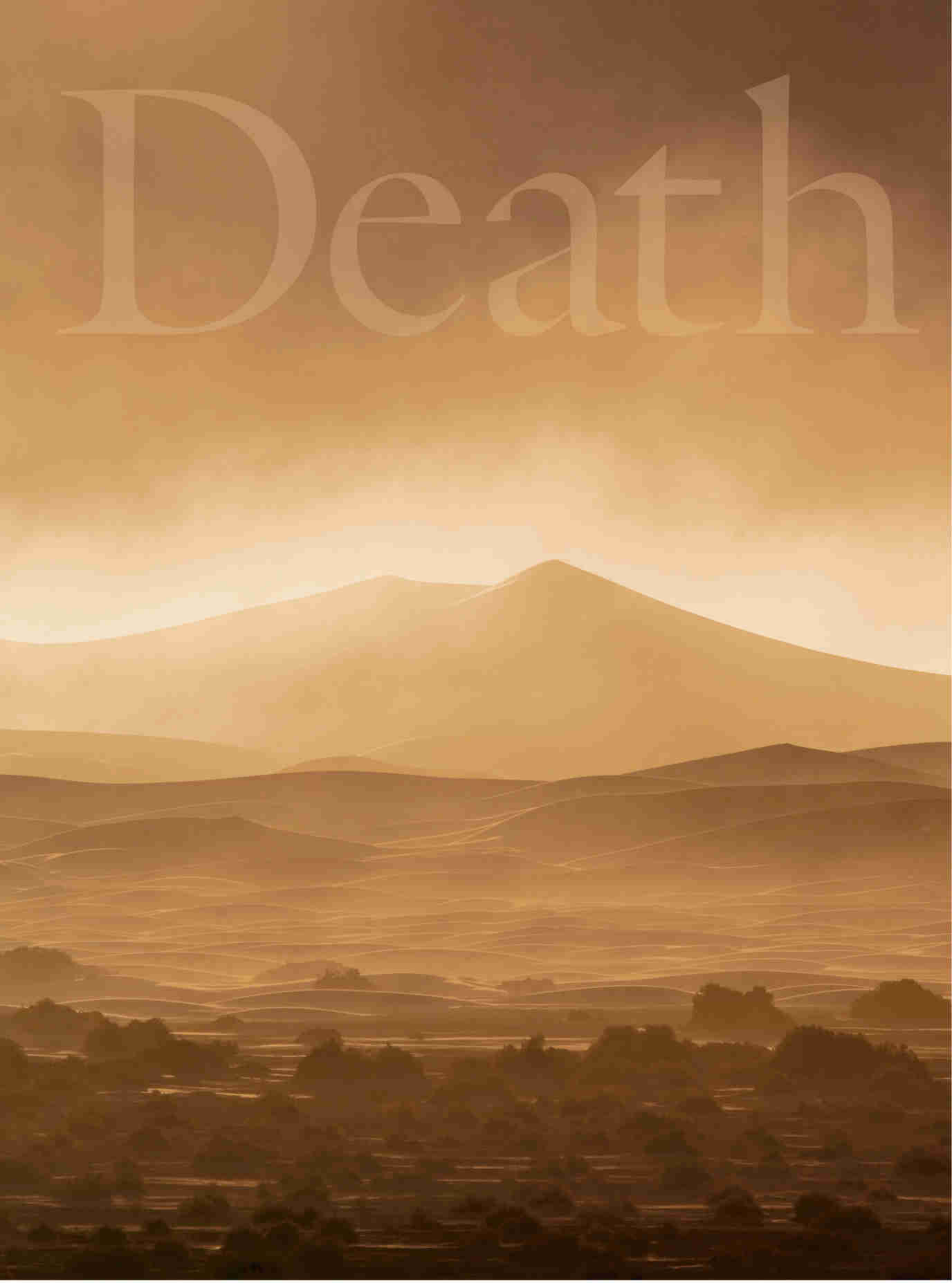
We flew down the long royal driveway and reached breakneck speeds on the byroads of Nuku'alofa. Two months later, in November 2006, most of the city's downtown would go up in flames during a second wave of political riots. Thick black smoke would hang over the city, as crowds flipped cars, set fire to offices, and threw stones at government buildings, demanding more democratic representation. Eight people would die, hundreds would be arrested, and five democratic leaders—including 'Akilisi Pohiva—would be charged with sedition.

For now, though, Moala dodged slower cars and reflected on His Royal Highness.

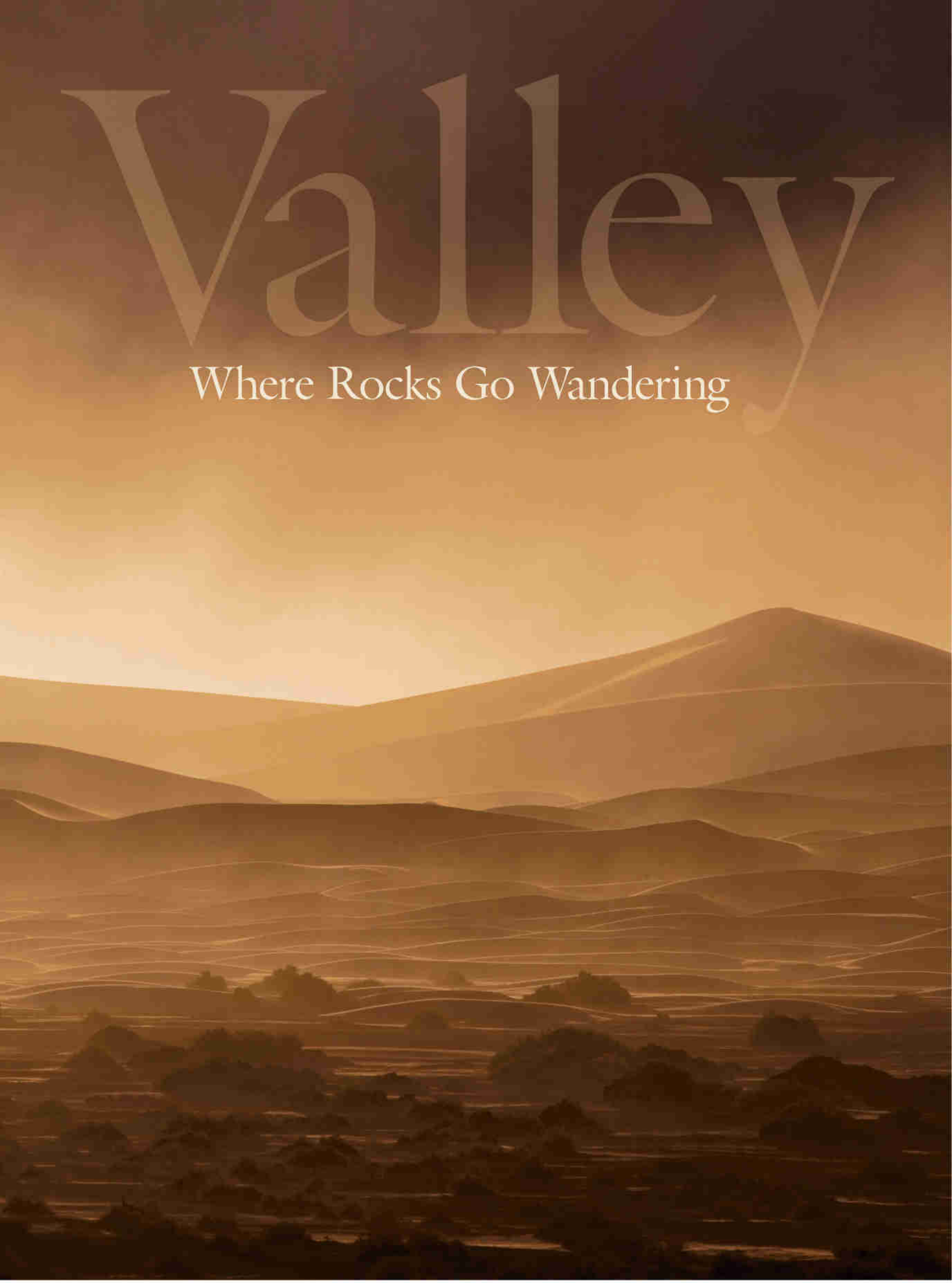
"Up to one week I don't see him. He just stays in his room. He gets the food taken to his room, up to one week," he said. "The HRH stays lonely in his room. Maybe he likes to stay by himself. But busy on computer. Stays on the computer all day and night."

I knew what he meant: The new king remains asleep, and everyone is afraid to wake him. □

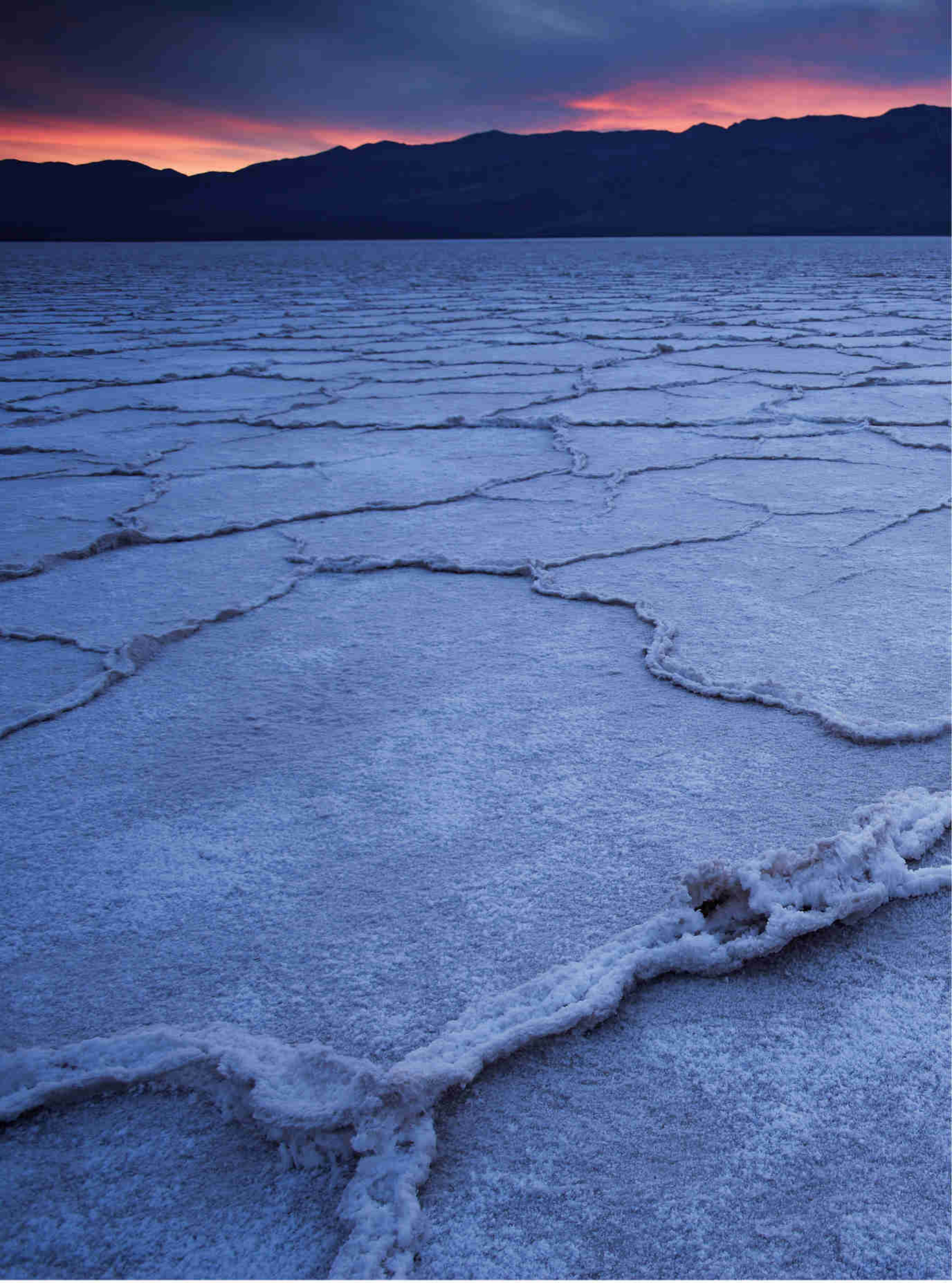
**Taste of Tonga** Photographer Amy Toensing shares her impressions and more images of this Pacific kingdom at **ngm.com**.




76 In America's hottest, lowest—and perhaps strangest—place, strong winds blow sand across a




flat, past tumbles of mesquite and arrowweed bushes, sculpting restless dunes beyond.



78 At 282 feet below sea level, Badwater Basin is North America's lowest point. When it floods, the

shallow pools evaporate quickly, leaving polygons of mud encrusted with shimmering salts.

80 West of Salt Creek, raging streams have carved shallow canyons into sediments laid down in

former lakes over five million years. Iron oxides in the deposits paint the landscape in varied hues.

By Tim Cahill • Photographs by Michael Melford

I imagine the sight of Death Valley National Park is something akin to scientific pornography for hard-rock geologists. There are the obvious soaring mountains and abysmal valleys, of course. But in most other places on Earth, the folding and buckling of rocks, the colliding of crustal plates, the shores of advancing and retreating lakes, the evidence of volcanic activity, the scrape of glaciers across rock, the subtle and not so subtle effects of erosion are covered over in grass or dirt, in snow or ice. The Earth is a modest mother, but Death Valley is, for the most part, naked.

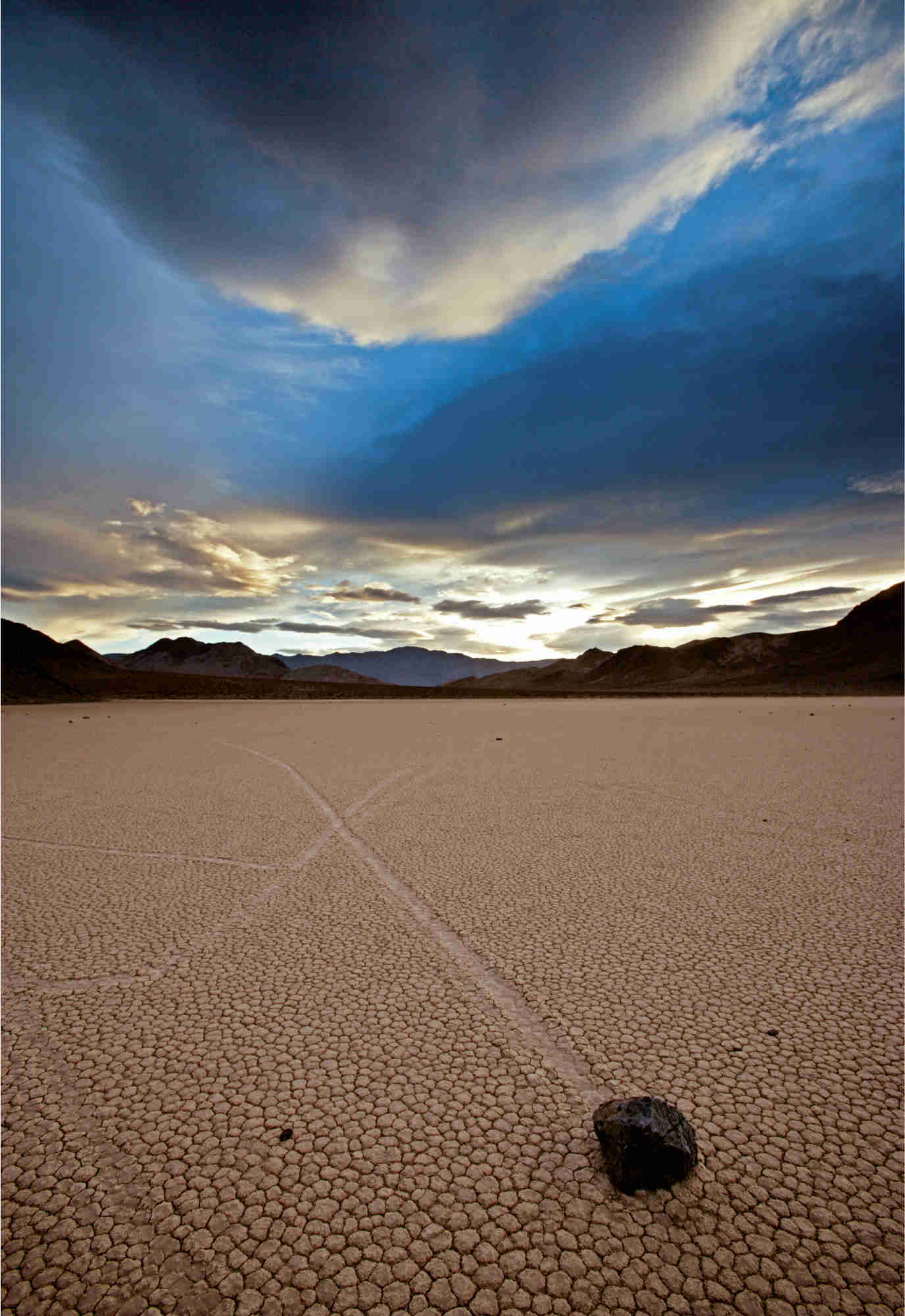
It is also the only place on Earth where geology itself has made me laugh out loud. I am thinking specifically of an area in the northwest section of Death Valley called the Racetrack, where, inexplicably, rocks as big as microwave ovens go zipping across the desiccated mud for distances of more than half a mile. The evidence is all there: deep tracks in the surface, with a rock at the end. One concludes, reluctantly, that the rocks somehow traveled a couple of hundred yards, leaving a telltale trail behind. There are over 150 of these roving rocks. But no one has ever seen them move.

The Racetrack proper, about three miles long and a mile wide, is what is called a playa, a dry, smooth lake bed. The Racetrack is a mere two inches higher on the north end than the south. Flat as a pool table. The surface is sun-baked mud, hard as rock, and patterned in polygons the size of doughnuts. It is an otherworldly sight, and there is a sense on the playa of post-apocalyptic silence, broken only by the whisper and wail of the wind. This impression is compounded by the Grandstand, a 73-foot-high island of rounded bedrock at the north end that looks like the summit of a mountain buried in a sea of sediment. One supposes that observers—rock-racing fans—might sit on the Grandstand, as at a horse race, and observe stones zooming toward them from the southern end of the playa.

I had plenty of time to contemplate the Grandstand. I'd driven 30 miles from Ubehebe Crater, and the gravel road proved to be less brutal than expected, so I arrived at the Racetrack in the early afternoon. The best time to see the rock raceways is around dawn or dusk, when the slanting rays of the sun show the tracks to their best advantage.

To pass the time, I climbed to a ridge off nearby Ubehebe Peak for one of the most spectacular views in the park. On this February day,

When the playa called the Racetrack gets wet, rocks of up to 700 pounds are believed to catch a wind and skim across like pucks on ice. No one's seen it happen, but tracks tell the tale.



I limped through labyrinthine canyons that gave way to mazes of strange, spooky rocks of the type Westerners call hoodoos.

the temperature stood in the low 70s and made for pleasant climbing. When I reached the ridge, the slope dropped off like a cliff to the west, where I could see the sands and salt pans of the Saline Valley 4,000 feet below. Farther west, just out of the park, were the Inyo Mountains, in the Inyo Mountains Wilderness, capped with snow and rising to 11,000 feet. They were beginning to cast their shadows into the Saline Valley. Beyond the wilderness, the Sierra Nevada, all snow from my perspective, towered over the Inyos.

And that is one definition of Death Valley: It is a land of intense vertical relief. This is true of most of southeastern California, a region torn by earthquakes, once flooded with vast inland seas, and eroded by wind and rain. Nevertheless, it is primarily rising mountains and falling valley floors that create the astonishing counterpoint of land that lies hundreds of feet below sea level guarded by peaks rising two miles above. Slow tectonic torture corrugates the landscape as two massive crustal plates meet and slide past each other under California: the Pacific and North American plates. The ridge on Ubehebe Peak was a good place to contemplate this ongoing process.

When I turned around, to the east, I was looking directly down onto the Racetrack and the Grandstand. In the desolate wind on the exposed ridge, the Grandstand rocks looked like the very tips of buried buildings, like an undiscovered city swallowed up in silt, like alien and interred skyscrapers.

At the far edge of the Racetrack a multigenerational Japanese family walking on the playa looked as if they were skating across an ice rink. Soon enough, I was walking on the flat, feeling a mild sense of vertigo, a bit of dizziness that suggested I might just fall off. How? Where? I don't know, but try talking sense to your inner ear.

At the south end of the Racetrack, where the playa abuts an 850-foot-high mountain face, rocks had tumbled from elevation out onto the playa. Some were the size of softballs, others suitcases. These rocks did not gather any moss. They were movers. Robert Sharp and Allen Glazner, in their book *Geology Underfoot in Death Valley and Owens Valley,* explain the process. The playa receives three to four inches of rain a year during winter storms and summer cloudbursts. Parts of the Racetrack flood. Fine, intensely slippery clay settles, and the winds, which may reach 90 miles an hour, must overcome the forces of friction for the rocks to break free. Once that happens, it takes only about half the wind power to keep the rocks moving.

There were levees a fraction of an inch high on either side of the tracks, and mud had piled up in front of the rocks. Looking at it all, I had no doubt that the rocks had sailed before the wind.

Some rocks made straight paths, some curved. Some traveled a hundred yards in one direction, stopped in a muddy muddle, apparently thought better of their direction, and made a 180-degree turn to ramble off in another direction. Some trails were wide for a while, narrow, then wide again. Occasionally, half a dozen rocks took off at once from the base of the mountain and seemed to race straight toward the Grandstand like horses at the derby. The tracks often crossed one another. I followed dozens of them, and when I found the rocks at the terminuses of the tracks, they seemed almost sentient. Why this made me laugh, I cannot say.

Robert Sharp and *(Continued on page 90)*

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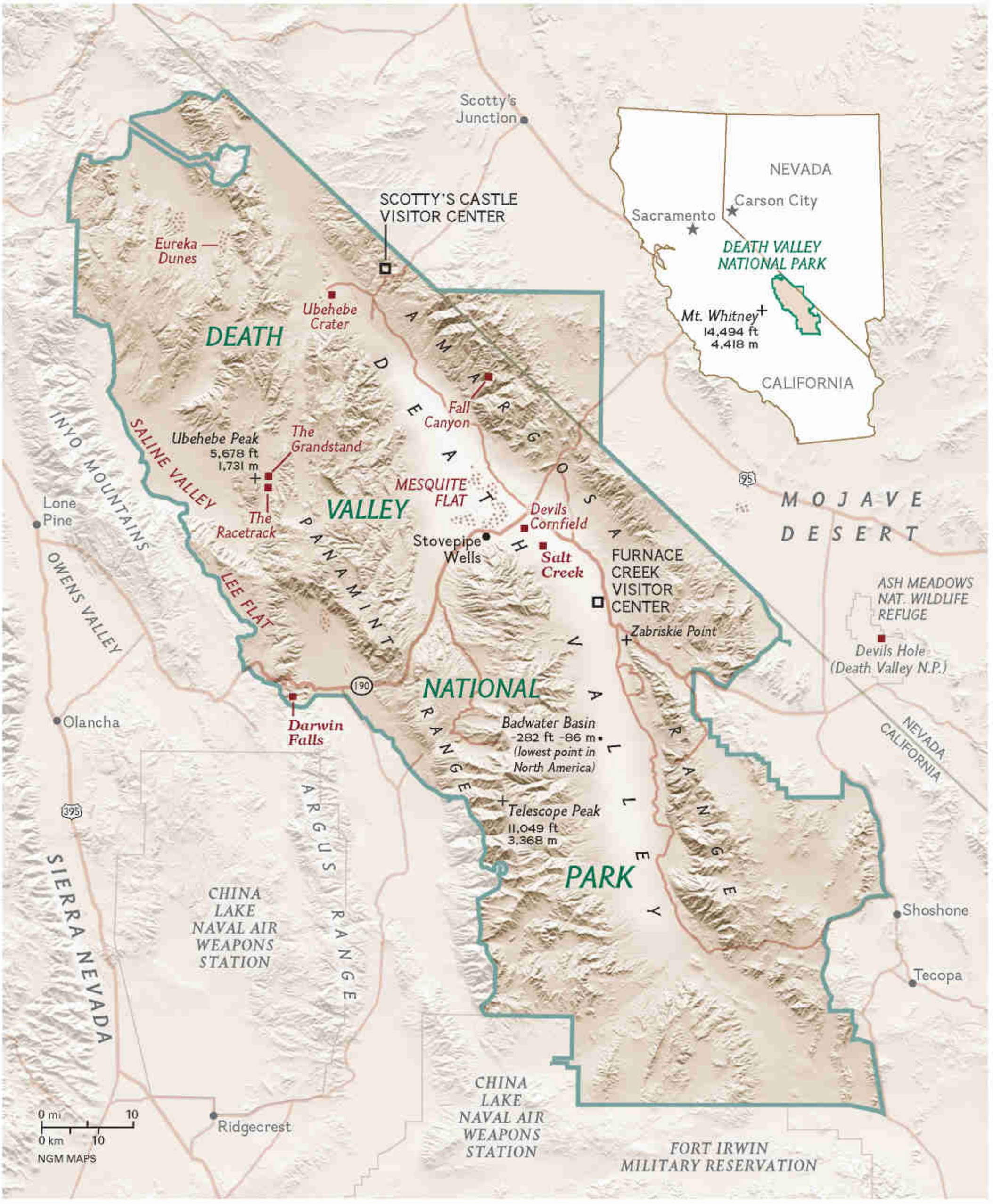
*Tim Cahill is the author of nine books, including* Lost in My Own Backyard: A Walk in Yellowstone National Park. *Landscape photographer Michael Melford is a frequent contributor to the magazine.*




# A Place of Extremes

At 3.4 million acres it's the biggest national park outside Alaska and has the most scorching temperatures (up to 134°F). Mountains to the west keep it arid: Precipitation reaches barely two inches a year and dries up in a flash.

86 Thrust up, twisted, and eroded, the Amargosa (foreground) and Panamint Ranges have been

pulling apart for millions of years. Death Valley formed as the land between them dropped.



Swept across Mesquite Flat by howling gusts, grains of sand skitter up the windward sides of

hundred-foot-tall dunes and plummet down their back slopes, driving a slow march of sand.

*(Continued from page 84)* Dwight Carey studied the rocks starting in 1968, concentrating on 30. The geologists put an erasable letter on each and, charmingly, gave the stones women's names: Hortense (R) moved 820 feet in one winter. Karen (J), a 700-pound rock at the end of a 570-foot-long track, didn't move at all during their seven-year study and disappeared years later. Karen showed up again in 1996, when Paula Messina, a geologist at San José State University who had been mapping the paths of all the sliders on the Racetrack, found her far north of where Sharp had last seen her. "When I told him I had positively identified several of his original rocks, his reaction was a little like one would expect from a man who was just told I found his children."

*Geology Underfoot* was helpful in deciphering some of the tracks. Most rocks that sailed a straight course would have protruding lumps on the bottom, and you could see those striations in the track itself. Essentially, they'd been sailing with a keel. Perfectly smooth stones, without keels, might curl about in a graceful arc. Tracks might be wide where a rectangular stone sailed sideways against the wind, and they might narrow if the stone turned lengthwise.

It was getting dark on the Racetrack, and I walked back to the car, about half a mile away. A Park Service sign near the car read: "Please do not remove the rocks; they become essentially meaningless when moved out of place."

I'd walked across Death Valley a quarter of a century ago. At the time, it seemed like a good idea: Walk from the lowest spot in the United States—Badwater Basin, in Death Valley, 282 feet below sea level—to the highest point in the contiguous states, Mount Whitney, 14,494 feet high and just less than a hundred miles away. It was summer, and my partner and I started off in the cool of the night. We would run into problems we had anticipated but not appreciated.

The valley is young. It was created by about two million years ago when the land between separating mountain ranges dropped along faults. The mountains, including Telescope Peak, at 11,049 feet the highest in the park, which loomed over us in the moonlight, catch what moisture reaches them. The water runs down steep slopes, causing erosion and mudflows, building alluvial fans, and eventually finding the lowest spot, as water will do.

The valley wants to be a lake, but the heat and constant winds cause water to evaporate and leave behind a residue of minerals, mostly salts. The ground temperatures can rise to 200 degrees Fahrenheit, and the earth itself is baked hard and flat, like concrete. But out toward the center of the valley, the would-be lake asserts itself. It is covered in only a very thin layer of minerals that would not hold my weight. I crunched through to lukewarm water and mud, sinking up to my calves, then my knees. It was like walking on crusted snow: With each step, you think the crust will hold, but when you put your full weight on it, you crash through. It was hard, sweaty work, postholing through the salty bog located in the lowest place in North America.

Worse, my mind was occupied with tall tales told by prospectors and desert rats. It was said that a team of horses or a man may have been swallowed up by the bog, never to be seen again. One fellow said he'd found a dead man, buried to the neck. "He was a Swede with yellow hair," the man said, "and he died staring at the sun. He sank standing up."

The stories are surely apocryphal, but the bog on that hot moonlit night seemed endless, and I kept thinking of the scalded and surely spurious Swede, staring at the sun.

"You want to go ahead?" I asked my partner.

"Shut up and walk," he said.

And so we did, eventually summiting Mount Whitney, which was a walk up. If we'd gone in the winter, it would have been a technical mountaineering expedition, which is why we walked across Death Valley in the summer.

At which time, according to Christopher C. Burt in his book *Extreme Weather,* Death Valley is "far and away the hottest location in North America." The valley's absolute maximum temperature of 134°F is the highest ever recorded in the Western Hemisphere and second only to

Joshua trees often grow with four and five and even six arms, their branches festooned with green, bayonet-like leaves.

A sparse stand of Joshua trees qualifies as a forest on Death Valley's western edge, where a dust storm turns day to twilight. With little water to share, the trees keep their distance. That they should grow here seems a wonder, but at 5,571 feet, Lee Flat is far cooler than the valley floor. Moisture from rain and snow lasts long enough to trickle down to thirsty roots.

Death Valley is, for the most part, naked.
It is also the only place on Earth where geology itself has made me laugh out loud.

What looks like a walrus's grizzled face is actually a lesson in the limits of persistence. As wind scours away surrounding ground, only sandy hummocks anchored by the stubborn roots of arrowweed plants remain. It's an eerie landscape: the Devils Cornfield. Eventually, winds can carry away so much dirt and moisture that the arrowweed withers and dies (foreground).

a reading of 136°F measured in Al Aziziyah, Libya. Because of the high July temperatures, however, Burt is willing to say that Death Valley is "perhaps the hottest place on the planet."

So my stroll across the valley wasn't as pleasant as it might have been in, say, February. The hot mud clung to my boots, and as the sun rose and the temperature approached 120°F, the boots baked themselves into odd punishing shapes. But the slopes of the Panamint Range were a revelation. I limped through labyrinthine canyons that gave way to mazes of strange, spooky rocks of the type Westerners call hoodoos. On the upper slopes, there were green trees and small streams, even a waterfall. That kind of contrast in less than 24 hours of walking excited a wonderment in me. I wanted to go back and explore Death Valley when it was relatively cool, and that took 25 years.

There is no sign for Darwin Falls on the highway—you have to make the turnoff before you'll see a sign. This is because the Park Service hides signs for certain attractions. I think this is a good idea. But no one wants to miss Darwin Falls, which features an 18-foot plunge into a shallow pool surrounded by maidenhair fern, impossibly green under beige sun-scorched cliffs. The mist from the falls cools the air to, I'd say, ten degrees lower than the open desert, and there is watercress at the pool. The water itself feels cool.

Even in February, with temperatures in the low 70s—and low 60s near the pool—it is tempting to take a quick dip in the water, but this is the drinking supply for a nearby resort, and swimming is highly impolite. Also, in the post-9/11 world, messing with someone's water supply is not a good idea: The ill-mannered swimmer could be charged with terrorism.

From the falls, I drove several thousand feet up into the mountains on Highway 190, making for the Saline Valley turnoff. The pass took me to a forest of Joshua trees. They are widely spaced plants, and they often grow with four and five and even six arms, their branches festooned with green, bayonet-like leaves, reaching to the sun. Legend has it that Mormon pioneers saw in them a resemblance to the biblical Joshua raising his arms to heaven or brandishing his spear.

After the sun had set on the trees of Lee Flat, the western sky had that bruised, purple look of things to come, and I set up a tent and laid out a sleeping bag.

Dawn. And yes, as hoped, it was snowing lightly on the Joshua trees. I wandered about in the forest, as wet snow accumulated on the green of the growing leaves, on the autumnal brown of the dead vegetation nearest the trunks of the trees. Joshua trees are signature plants of the Mojave Desert, and the concept of desert flora in the snow contained within it a quiet thrill. I was alone, and I owned this view. And just as I began feeling especially blessed, the rising sun turned the snow into a cold, bitter rain. No matter: I'd had my half hour of beatitude.

At Telescope Peak trailhead, 8,133 feet up, I prepared myself for the nearly 3,000-foot climb to the summit. Happily, I was stopped by snow almost immediately. From that point, I plunged down various roads, making my way north to the Eureka Dunes, which are up to 700 feet high. They make groaning sounds as rounded sand grains slide down their steep slopes, playing them as a musical instrument.

Later, I hiked many of the canyons—one of the great pleasures of trekking Death Valley. Sinuous, shady walls make for cool walking in Fall Canyon, where rocks were laid down in light and dark layers. In places, these layers arched like an angry cat and eventually fell over on themselves, so that the striations looped over and under even as they rose into another peak that likewise collapsed. It is plain to see: The bandings, like the rocks in the Racetrack, have definitely moved. At this spot, on a looming canyon wall, geology itself appeared to be in a state of agitated frustration. This wall of naked rock, exposed for all to see, seemed to be blushing crimson in the light of the setting sun.

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**Death Valley Lowdown** Take a tour and see more of Michael Melford's photographs in an interactive map at **ngm.com**.



Every chute in these bone-dry badlands was dug by downpours—torrents of water rushing

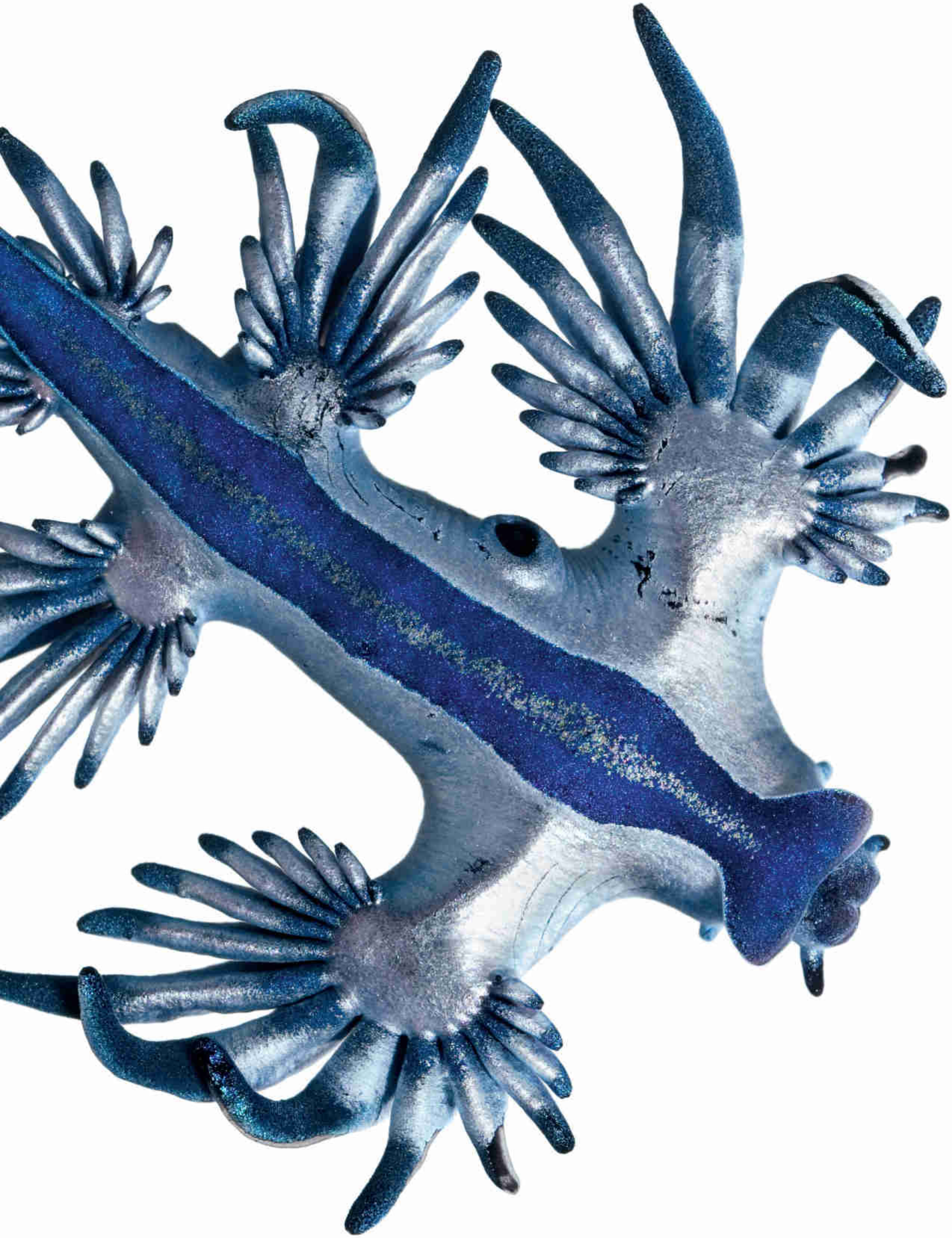
over easily eroded mudstone. Here and everywhere else in Death Valley, geology runs wild. □

# small wonders

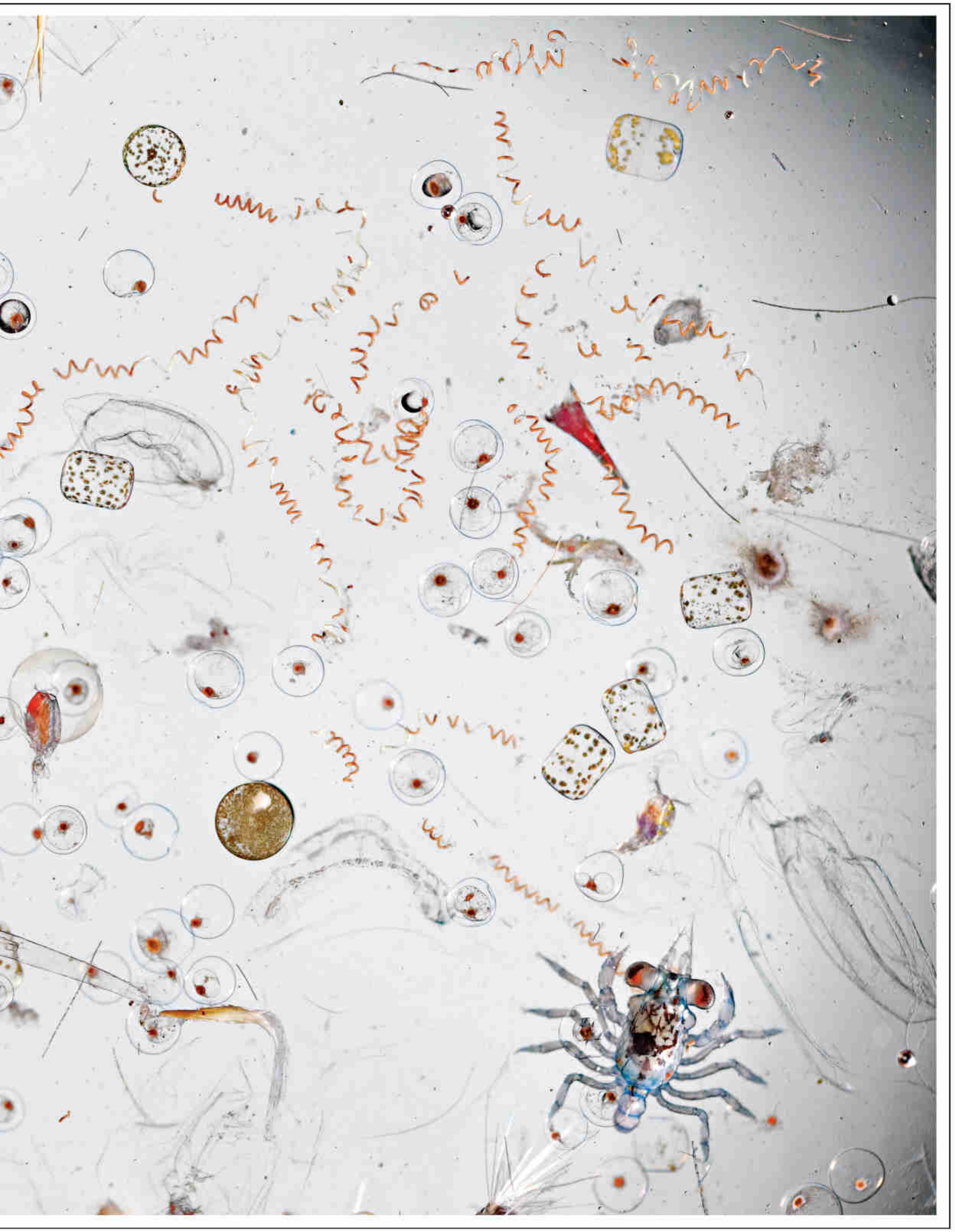
## *the secret life of marine microfauna*

No bigger than a quarter, a *Glaucus* nudibranch preys on toxic Portuguese men-of-war, appropriating their stinging cells for its own defense. Camouflaged in blue and silver, this sea slug was caught off Hawaii but drifts in mild waters worldwide.

*photographs by david liittschwager*

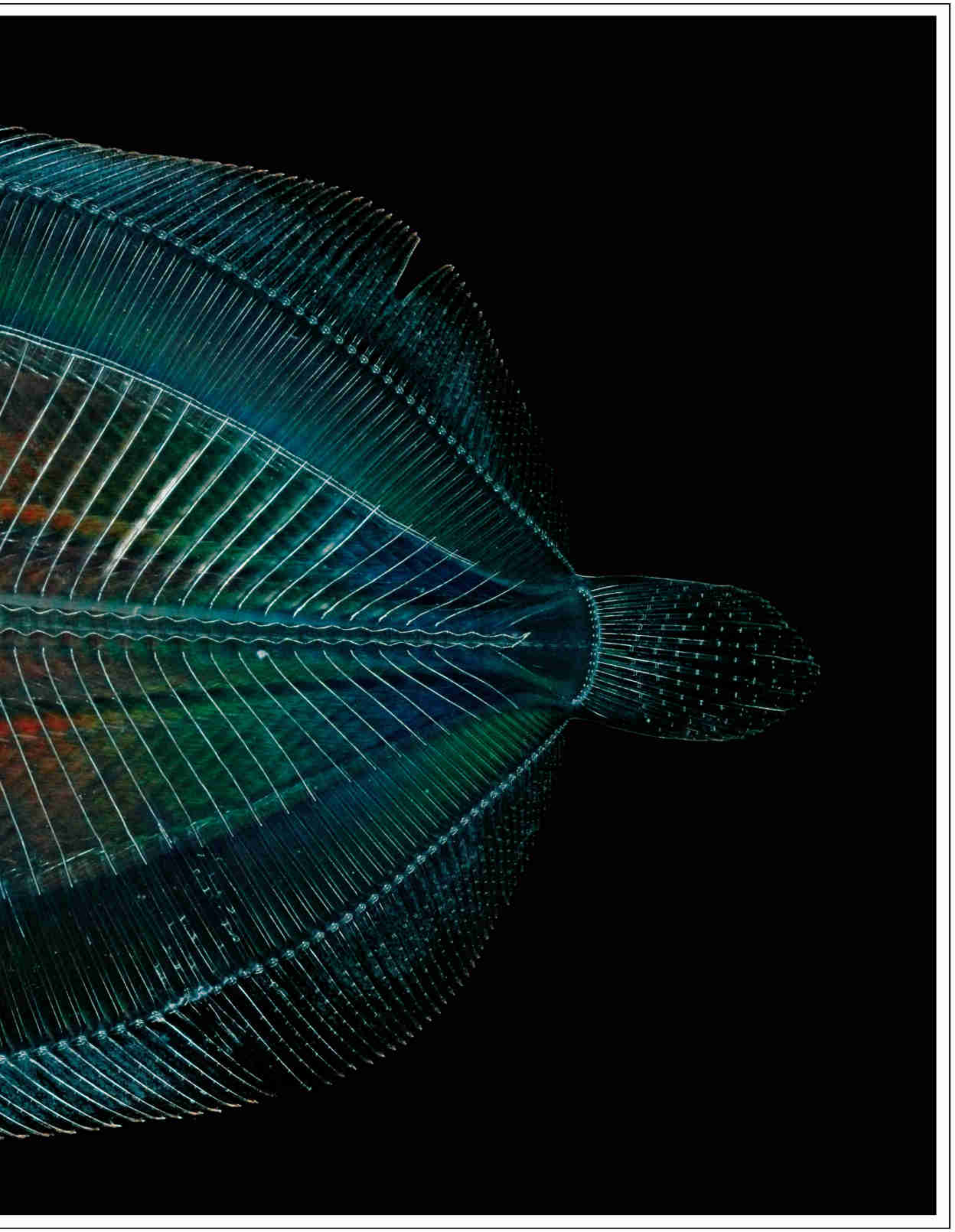


*GLAUCUS ATLANTICUS*, 0.75 INCH



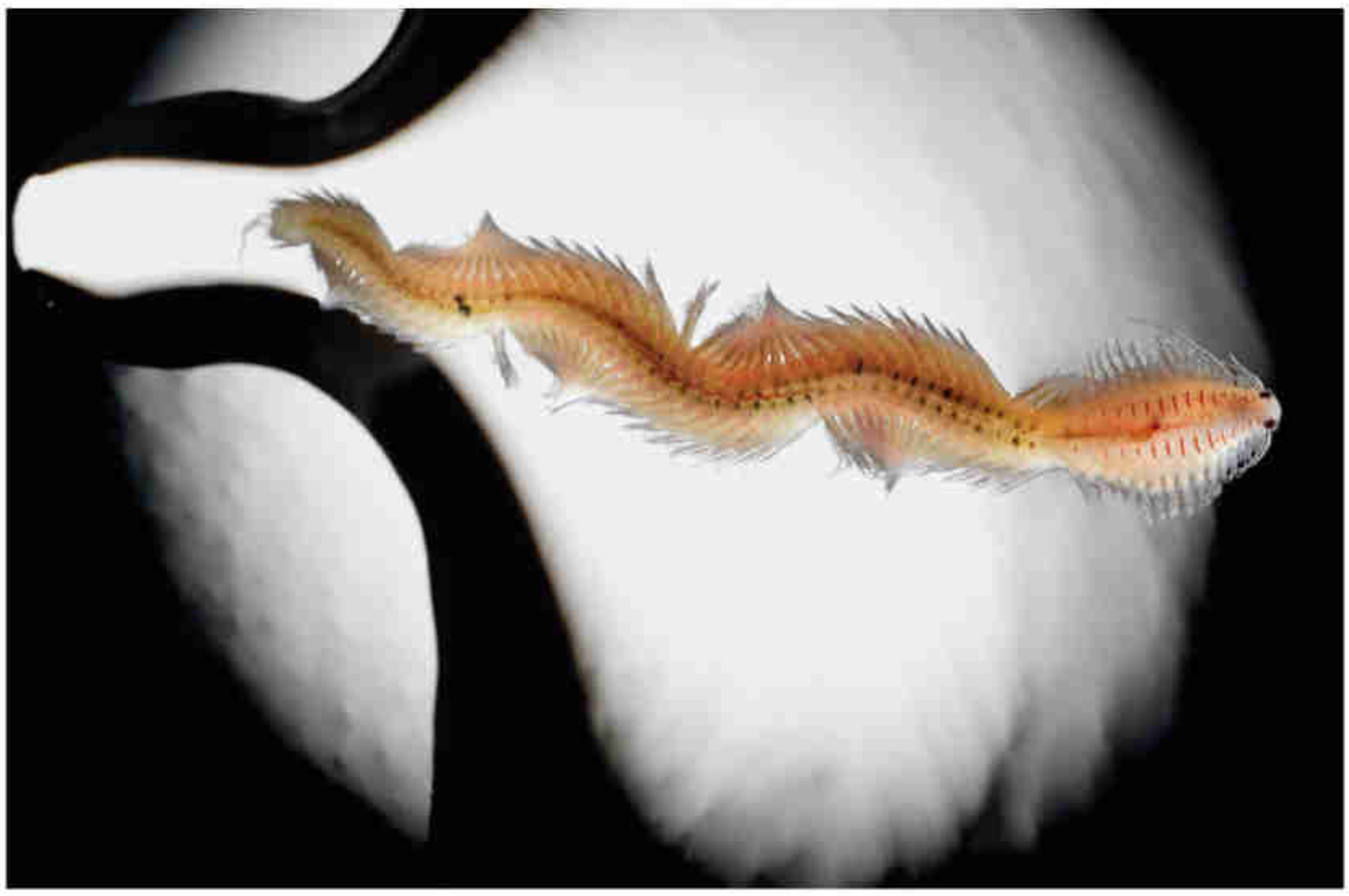
Magnified roughly 15 times, a splash of seawater teems with life. The planktonic soup includes bug-like copepods; long, glassy arrowworms; coiled filaments of cyanobacteria; rectangular algae called diatoms; fish eggs; and a big-eyed larval crab the size of a rice grain.

SAMPLE INCLUDES *ETHMODISCUS* DIATOMS, *KATAGNYMENE* CYANOBACTERIA, VARIOUS COPEPOD SPECIES, CHAETOGNATH WORMS



This larval flounder swims with other fish for now, hidden from predators by transparency (the color is an effect of lighting). It will soon be a bottom dweller that shimmies into the sand, gazing upward. Eyes start out one on each side; as the skull develops, one migrates to join the other.

*BOTHUS* SPECIES, 1.25 IN



**"Small is beautiful,"** declared economist E. F. Schumacher. Wise perspective for a planet where most organisms are built on a minor scale. A dipperful of seawater can reveal a hodgepodge of tiny free-swimmers and nebulous drifters that fog the water column. Many are microscopic. Others would be visible except they're virtually transparent. Gelatinous shape-shifters lazily ride the currents. Familiar forms in miniature—wide-eyed fish larvae, baby squid and octopuses—dart freely. Their lives are precarious. Some wear shells or exude toxins against predators; others are active only after dark. But untold numbers succumb to hungry mouths—each other's or those of bigger foes like grown-up fish and whales that vacuum up biomass.

To see the show, photographer David Liittschwager joined scientists from the National Oceanic and Atmospheric Administration off the island of Hawaii. Inhabitants must specialize to survive in these open, nutrient-poor waters—making for rich diversity. Liittschwager sampled with a bucket and fine-mesh net; at night, he lowered lights as lures. What squirmed toward the glow? "A genuine riot of life," he says. The scientists kept some animals on board to confirm identities; the rest they returned to the sea.

Condenser lenses cast focused beams to outline see-through specimens; side lighting rendered a baby flounder iridescent, and a backlight exposed its developing bones and organs. Tinkering with light, Liittschwager captured the nearly invisible. —*Jennifer S. Holland* NATIONAL GEOGRAPHIC STAFF

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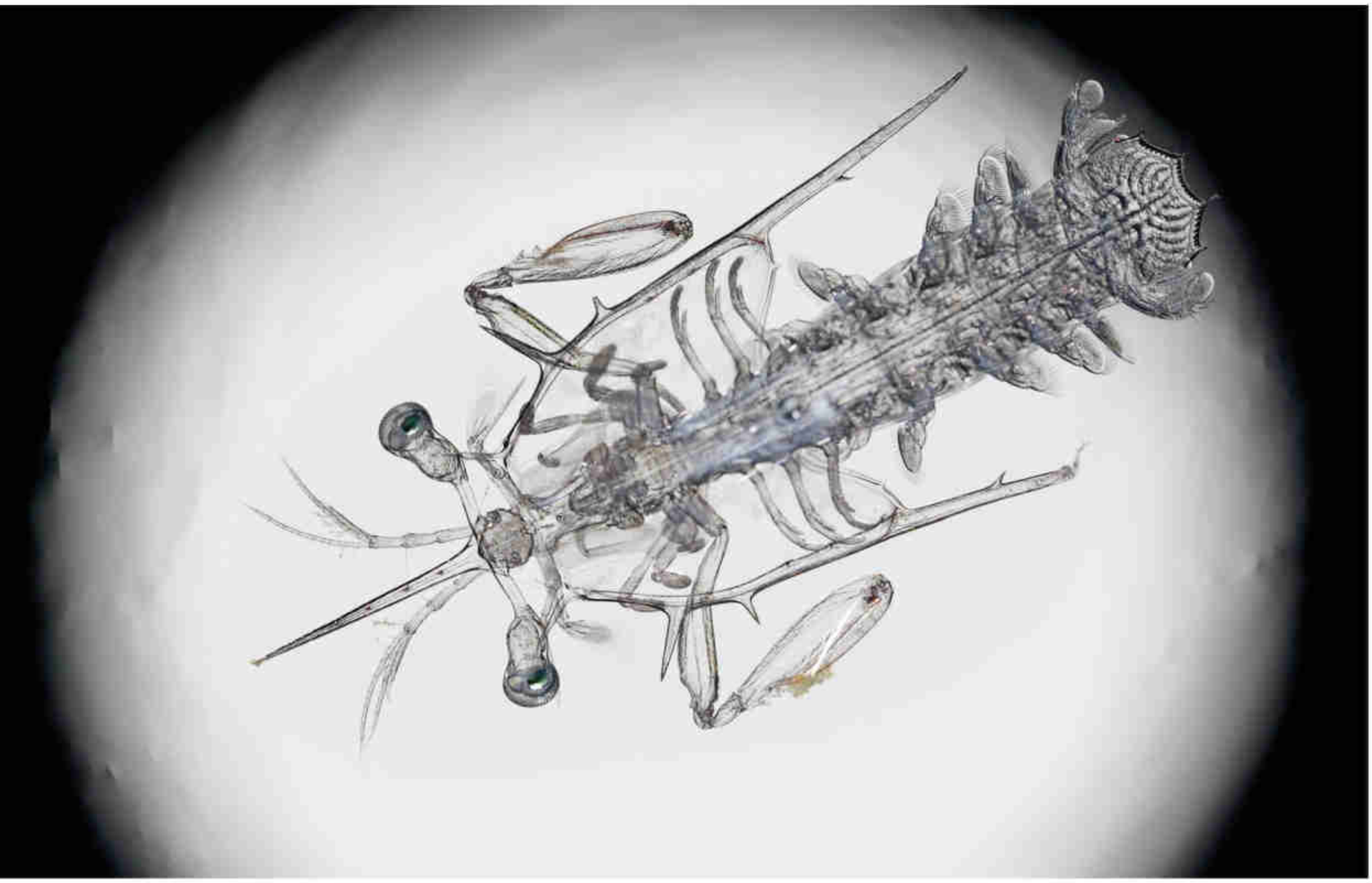
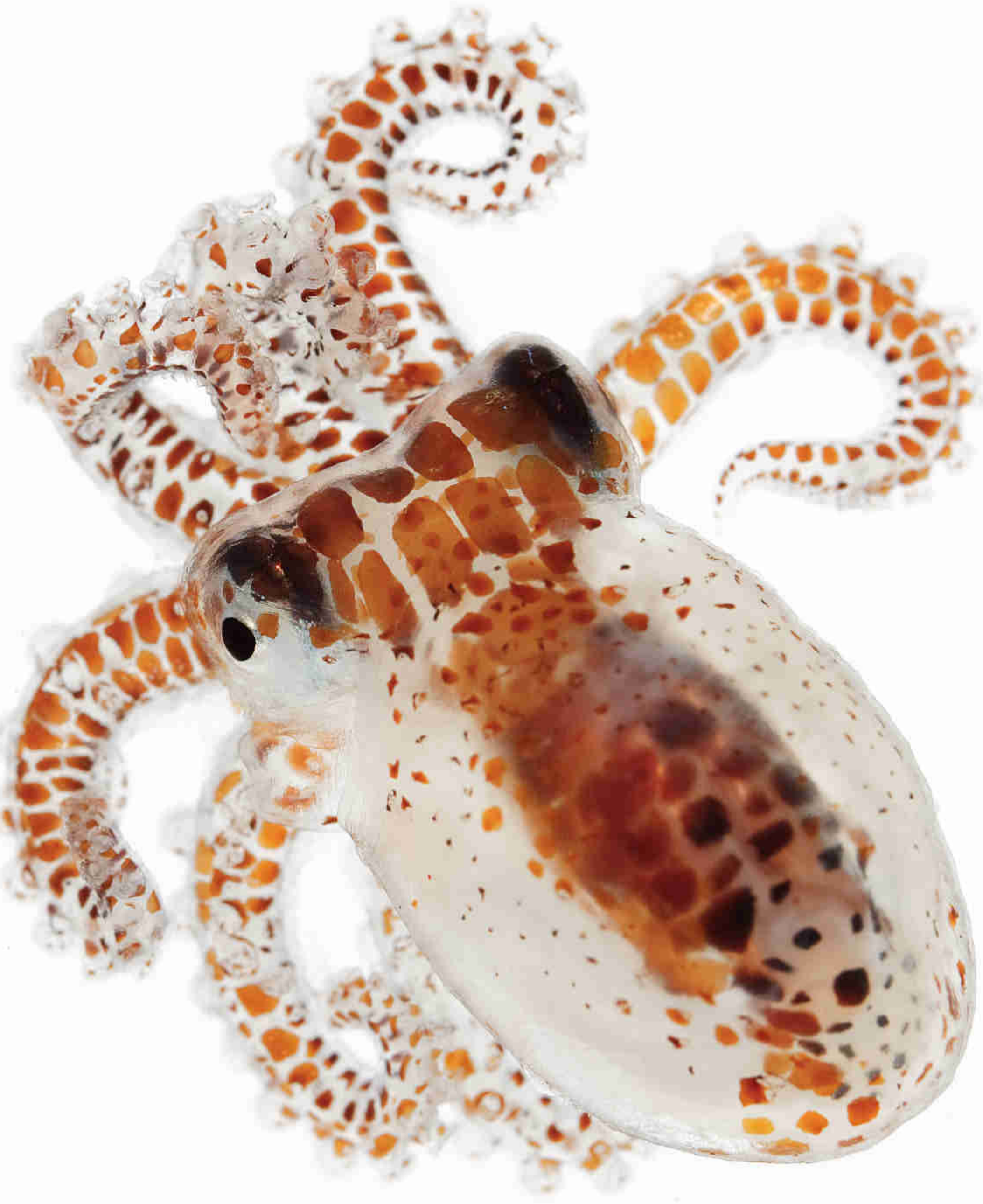
*Photographer David Liittschwager chronicles little-known ecosystems, most recently in his September story about cave life, "Discoveries in the Dark."*

New lives take shape. Fish eggs house developing embryos (visible, above right) and oil globules to nourish larvae. Transparency lets a mantis shrimp larva (below) hide in plain sight as it grows into a well-armed predator. As an adult, a polychaete worm (opposite, in a distorted water droplet) develops “oars” to paddle to the surface, spawn, and die.

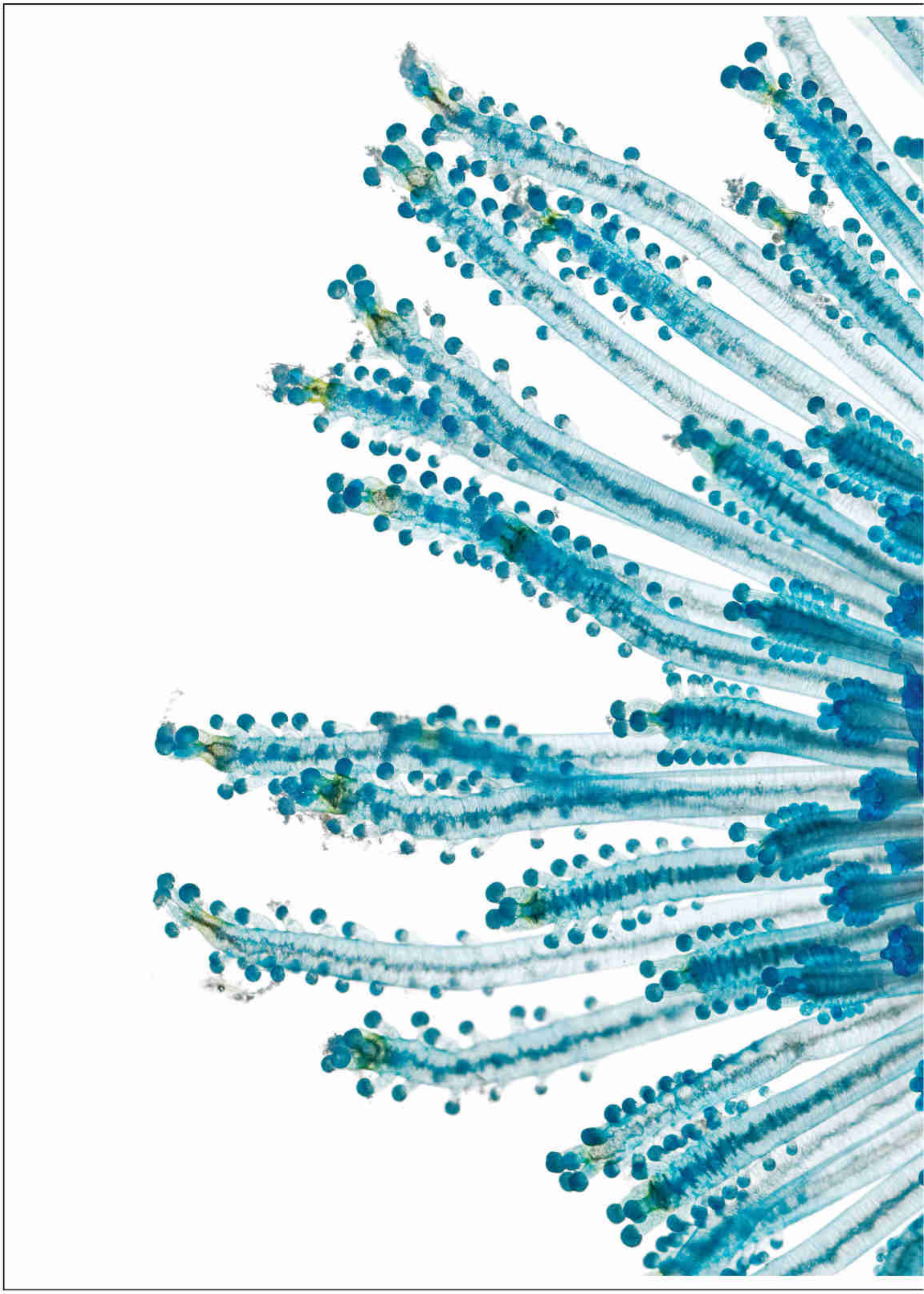


NEREIDIDAE (POLYCHAETE WORM), 0.6 IN; SQUILLIDAE SPECIES (CRUSTACEAN), 0.6 IN; SMALL EGGS, 0.05 IN; LARGE EGGS, 0.125 IN

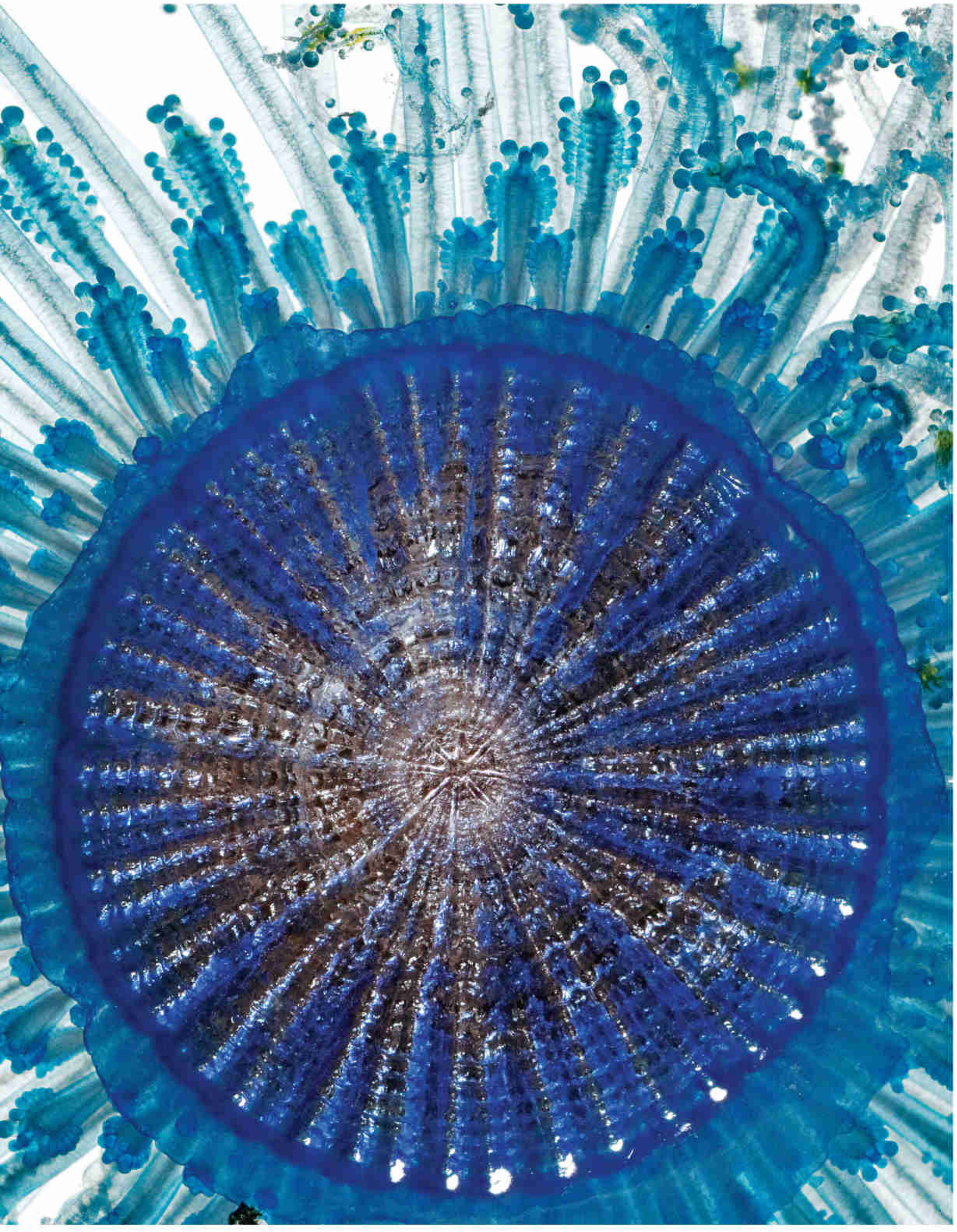
Weeks-old morsels like a swordfish (above), a slender mola (below), and a baby octopus (opposite) foraging in the open sea are easy pickings for larger animals. But the fish may survive to be giants themselves, the mola growing to three feet across, and the swordfish's snout and body stretching up to ten feet. The octopus, when mature, will stick to the seafloor, strong-arming prey and popping into hidey-holes for shelter.



*XIPHIAS GLADIUS* (SWORDFISH), 0.75 IN; *RANZANIA LAEVIS* (SLENDER MOLA), 0.125 IN; *OCTOPUS* SPECIES, 0.5 IN

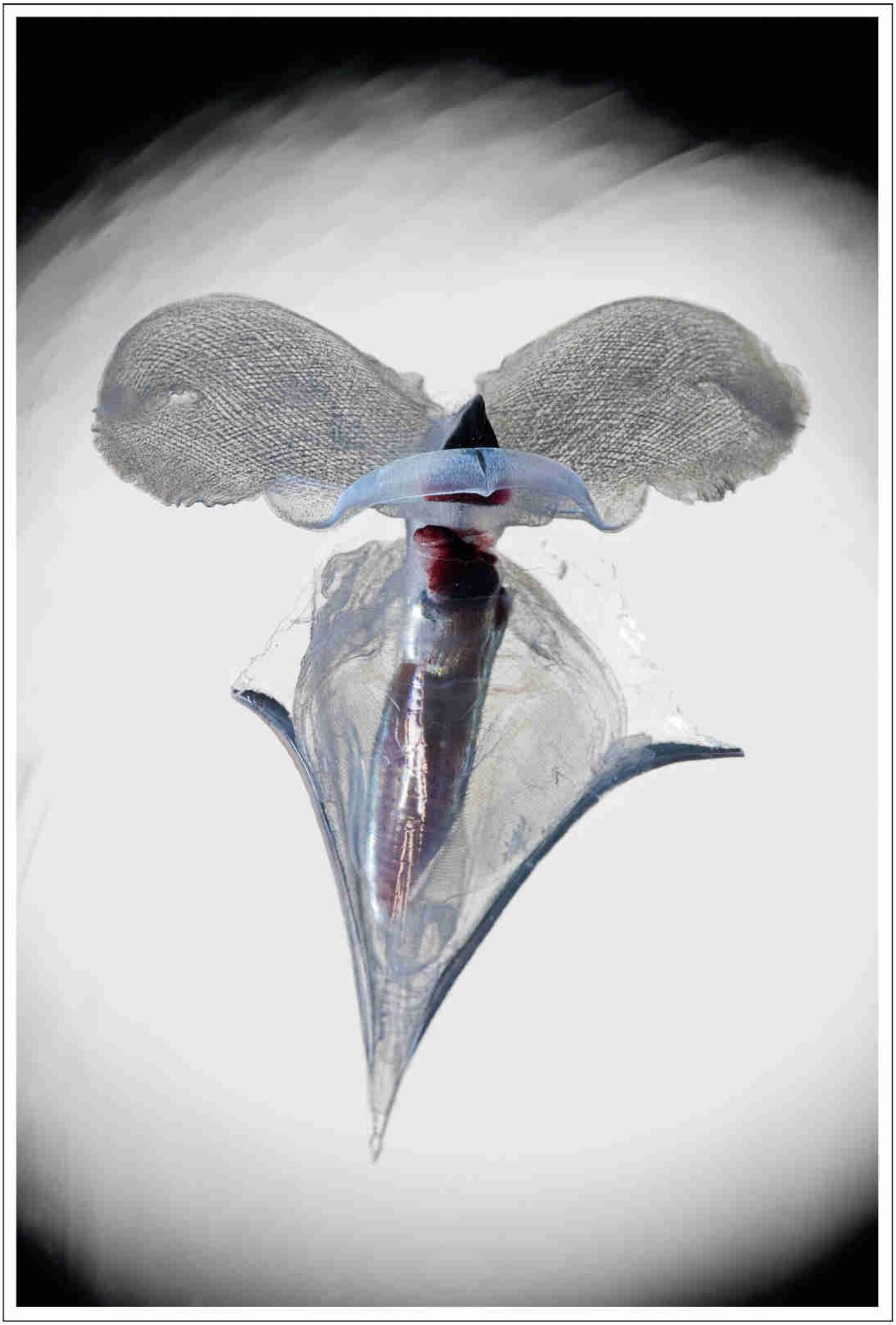


**Scoping Out Microfauna** View more miniature wonders, including a predatory snail and a larval flying fish, in a photo gallery at **ngm.com.**



A sunburst in blues, this jellyfish relative called a blue button isn't one organism but many, joined at the gas-filled hub that keeps the colony afloat. Each tentacle has a specialized role in the cooperative—catching prey, digesting, or reproducing. The pigment blocks ultraviolet rays.

*PORPITA PORPITA*, 1 IN



Spreading angel wings, a pteropod snail emerges from its fragile shell (above). The wings—actually a modified foot—propel the animal while it snares food with a sticky mucous net. A larval crustacean (opposite) seeks prey with its bulbous eyes; its spear-like rostrum serves for defense.

*CLIO PYRAMIDATA* (SNAIL); DECAPODA SPECIES (CRUSTACEAN). 0.5 IN (BOTH)

# the acid threat

*As $CO_2$ rises, shelled animals may perish.*

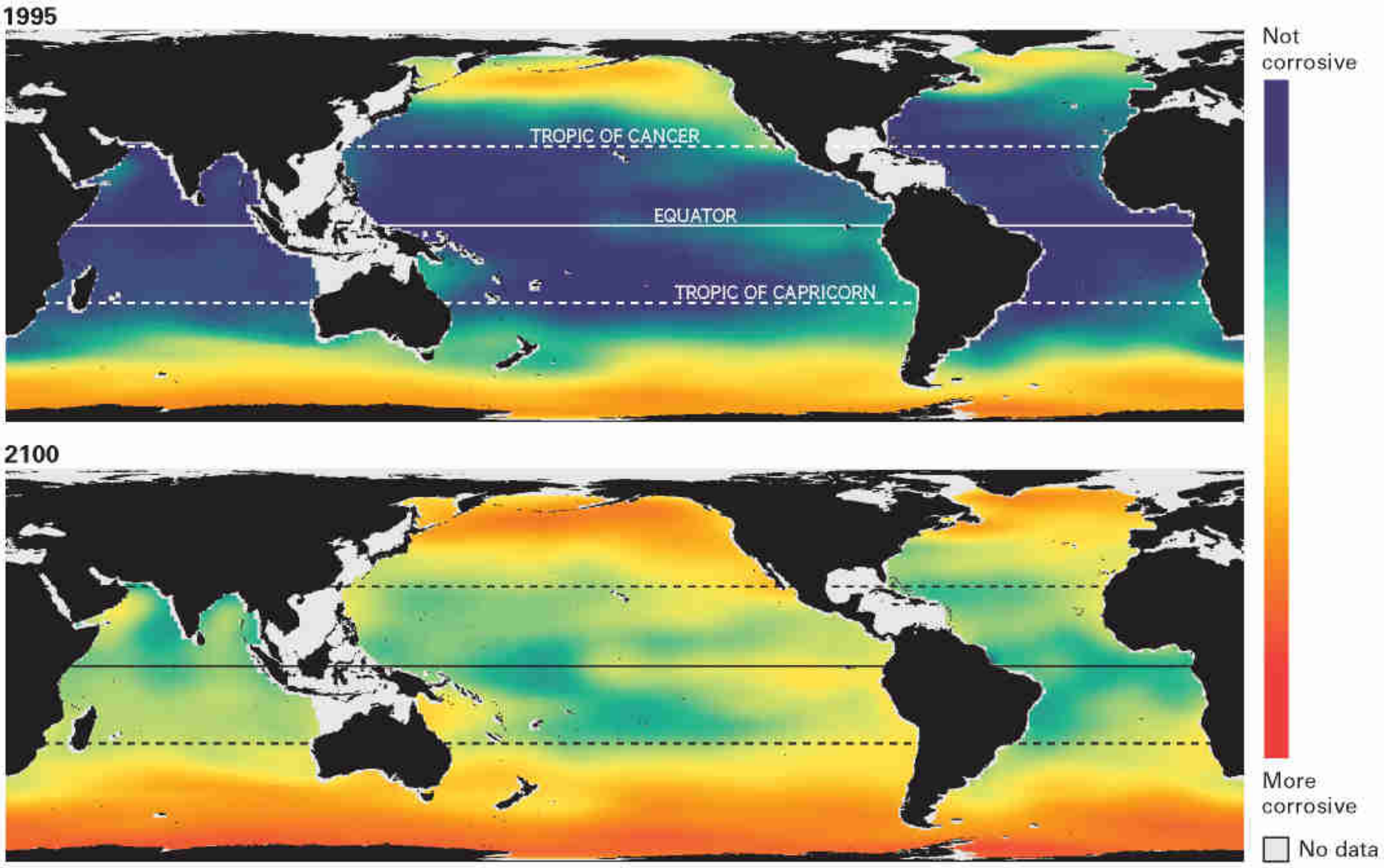
DAY 0 DAY 2 DAY 16 DAY 26 DAY 45

How might a shelled sea creature fare as increased carbon dioxide further acidifies the ocean? After just two days in seawater altered to mimic the dissolved $CO_2$ expected in the Antarctic Ocean by the year 2100, a pteropod's shell begins to pit and turn opaque; well before day 45 (last photo), all its hard carbonate has dissolved. "The test doesn't truly replicate oceanic conditions, but it shows how fragile a shell is," says marine biologist Victoria Fabry. A hit to pteropods and their ilk "will ripple through the food chain," she says. "It's very alarming."

Tiny creatures near the base of the marine food chain lead perilous lives at best. Now they face a man-made threat. No, not global warming this time, though the root cause is the same. As the level of atmospheric carbon dioxide ($CO_2$) rises, it is not only heating the globe but also dissolving in ocean waters, turning them more acidic. For shell-building animals that can mean a corrosive, even deadly environment.

Oceans are a natural sink for $CO_2$, already soaking up more than a quarter of what's released into the atmosphere. Today we're pumping out massive quantities—a surge that began more than a century ago as factories, power plants, and cars began devouring fossil fuels. By now the oceans are taking in 25 million tons a day of excess $CO_2$, and it is starting to show. Already scientists have measured a rise in acidity of some 30 percent in surface waters, and they predict a 100 to 150 percent increase by the end of the century.

No ill effects have been documented so far in the open ocean, but the threat is clear. Absorbed



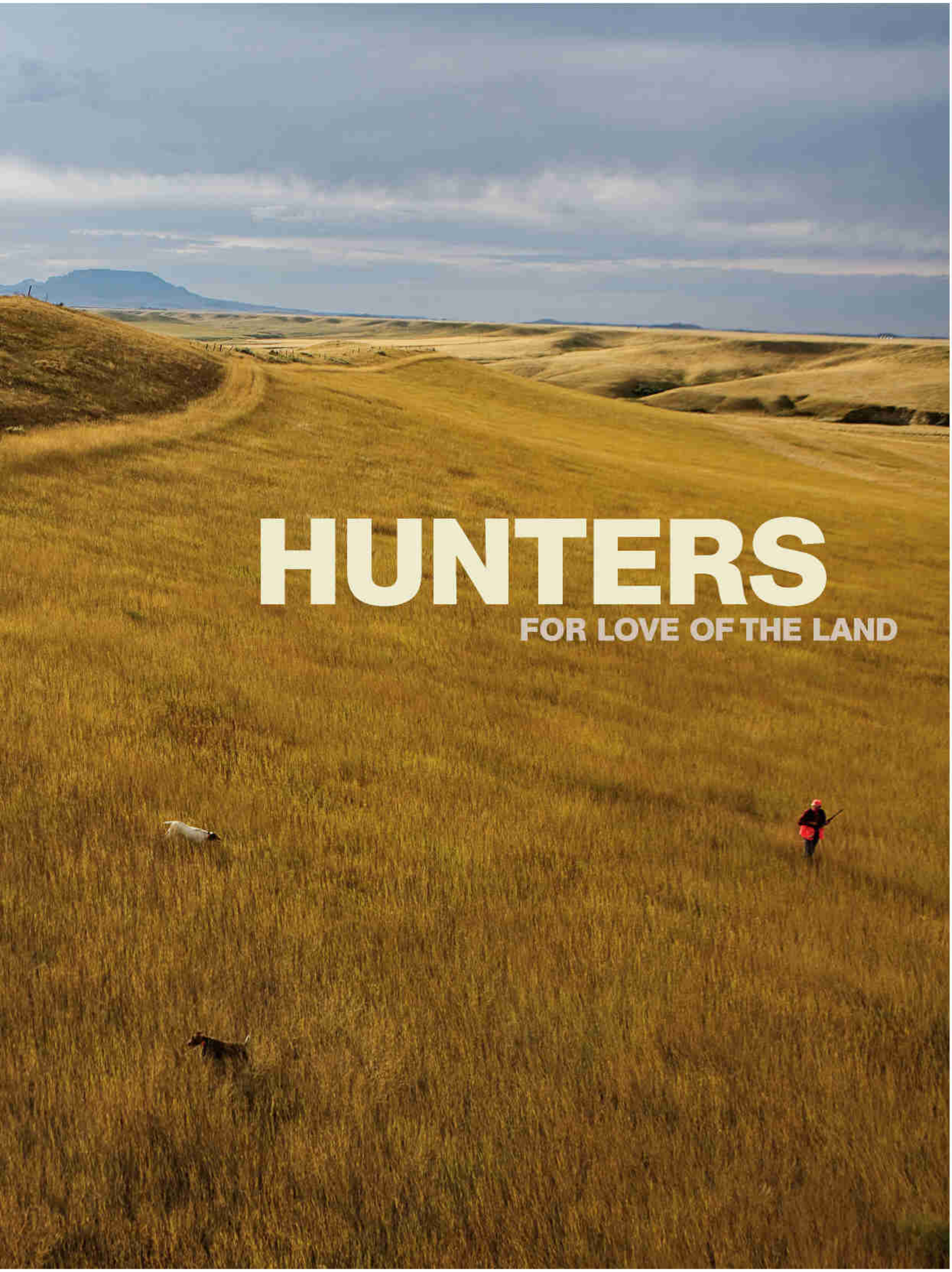

If $CO_2$ continues to rise unchecked, computer models show that acidification will deplete carbonate ions in much of the ocean by 2100, turning the waters corrosive for many shell-building animals.

by seawater, $CO_2$ reacts to form carbonic acid, which turns the normally alkaline water more acidic. In the process, fewer carbonate ions are left floating around—and many marine organisms, including mollusks and corals, rely on carbonate from seawater to build their shells and other hard parts. Eventually, vital species will no longer be able to build or maintain their shells and skeletons.

Users of the mineral aragonite—a very soluble type of calcium carbonate—are especially vulnerable. They include tiny pteropod snails, which help feed commercially vital fish like salmon. Computer models predict that polar waters will turn hostile for pteropods within 50 years (cold water holds the most $CO_2$, so it is already less shell-friendly). By 2100, habitat for many shelled species could shrink drastically, with impacts up the food chain. And as the acidification reaches the tropics, "it's a doomsday scenario for coral reefs," says Carnegie Institution oceanographer Ken Caldeira. If current trends continue, he predicts, reefs will one day survive only in walled-off, acid-controlled refuges.

Massive outbursts of $CO_2$ and other greenhouse gases have acidified the oceans in the geologic past, but equilibrium returned as the oceans stored away excess $CO_2$ in minerals on the seafloor. This time nature may be slow to heal. "Our emissions are huge compared with natural fluxes," Caldeira says. "If you could stop emissions and wait 10,000 years, natural processes would probably take care of most of it." These days we're simply dishing it out faster than the oceans can mop it up. —*JSH*

SOURCE: RICHARD FEELY AND DANA GREELEY, NOAA PACIFIC MARINE ENVIRONMENTAL LABORATORY. NGM MAPS




**PHEASANT HEAVEN** Sponsored by the conservation group Pheasants Forever, an 800-acre reserve on private land along Coffee Creek, Montana, provides prime wildlife habitat, open for hunting.

**WATCHING FOR WINGS** In the Mississippi River floodplain, Craig Hilburn and friends scan the skies near Stuttgart, Arkansas, for migrating birds. As director of conservation programs for Ducks

**Unlimited in Arkansas, Hilburn works to restore natural flooding patterns in degraded bottomland hardwood forests—important wintering habitat for waterfowl such as mallards and wood ducks.**

BY ROBERT M. POOLE

PHOTOGRAPHS BY
WILLIAM ALBERT ALLARD
NATIONAL GEOGRAPHIC PHOTOGRAPHER

**EYE TO THE FUTURE** **Mallory Martin, 14, joins the Annual Governor's Invitational Dove Hunt in Dickson, Tennessee. With the hunting population in decline—and the sport under fire from animal rights advocates—hunting groups and wildlife agencies are striving to enlist a new generation.**

The ducks came up from the basement: An opening wave of mallards, numbering 4,744, followed by battalions of black ducks, mergansers, pintails, shovelers, ringnecks, and canvasbacks, with a rear guard of more than 6,000 Canada geese completing the flight. It would take most of a week for the mixed flock of 22,963 birds to conclude the last leg of a long migration, which had begun with autumn, stretched into winter, and ended here on a damp January morning at the U.S. Fish and Wildlife research center in Laurel, Maryland.

It might be more accurate to say that these were metaphorical ducks and geese, with one part standing for the whole creature, because by the time they appeared at the Maryland research station, all that remained of each teal or scaup was one frozen wing, segregated by species and stored in a basement freezer to await the 2006-07 Atlantic Flyway Wing Bee.

Norman Saake pulled a mallard wing out of a cardboard box, fanned it so that the bird's steely blue speculum feathers flashed in the light, and broke into a smile. "You wonder how, after 30 years of doing this, a guy can get so excited about a pretty wing," Saake said, holding it up for the admiration of three or four others scrutinizing wings at his table. They cooed like grandparents looking at baby pictures. Saake, a biologist retired from the Nevada Department of Wildlife, had crossed the continent for yet another wing bee, one of several such events crucial to the health of the nation's waterfowl population.

Each wing told a story. By reading the feathers for a few seconds, a veteran like Saake could distinguish a mallard drake from a hen, a juvenile from an adult, a purebred mallard from a hybrid. After a week of sorting wings in Laurel, scientists could gauge if there were enough juveniles surviving in each species to replace adults in the population. Such surveys, combined with wing bee data and research from other regions, help resource managers determine how much hunting pressure each species can sustain from year to year. This is a prime consideration when the U.S. Fish and Wildlife Service sets its bag limits for the next hunting season—not only for waterfowl but also for woodcock, snipe, doves, and other federally protected migratory bird species.


"The age ratios really help show how a species is holding up," said Paul Padding, the Atlantic flyway representative of the U.S. Fish and Wildlife Service.

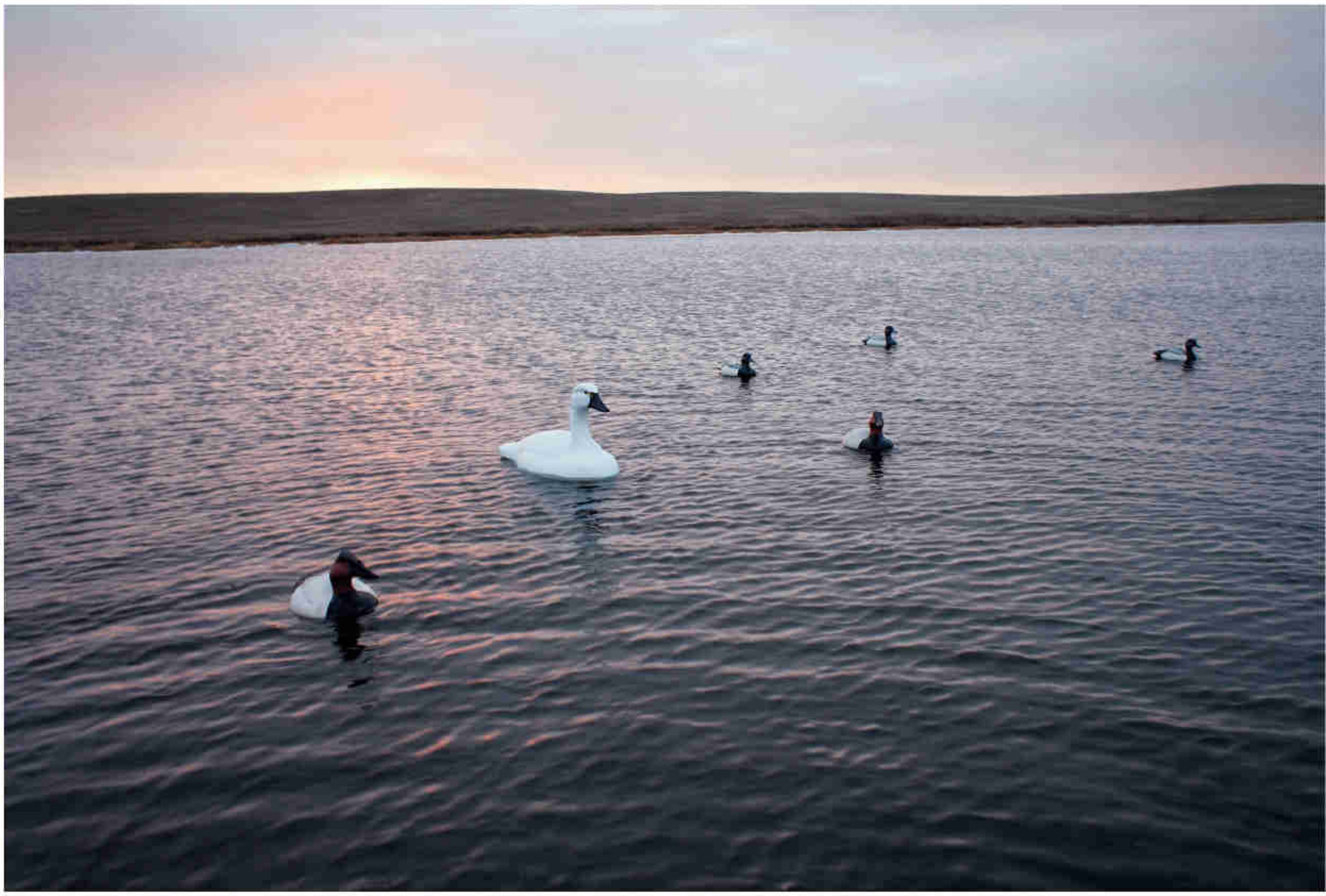
The great irony is that many species might not survive at all were it not for hunters trying to kill them. All the wings provided to Norman Saake and his colleagues throughout the country come from hunters, who fold them into prepaid envelopes, record the date and place of harvest, and mail them in. It is but one example of how the nation's 12.5 million hunters have become essential partners in wildlife management. They have paid more than 700 million dollars for duck stamps, which have added 5.2 million acres to the National Wildlife Refuge System since 1934, when the first stamps were issued (above). They pay millions of dollars for licenses, tags, and permits each year, which helps finance state game agencies. They contribute more than 250 million dollars annually in excise taxes on guns, ammunition, and other equipment, which largely pays for new public game lands. Hunters in the private sector also play a growing role in conserving wildlife.

TED TURNER, who is a hunter as well as a media pioneer, is also the country's largest private landowner. He has worked tirelessly to restore the American bison through much of its range. Now he manages some two million acres in the U.S. for biodiversity and for sustainable

1934 DUCK STAMP: COURTESY U.S. FISH AND WILDLIFE SERVICE

**RITE OF THE SEASON** On Mike Neuharth's farm in Eureka, South Dakota, Chad Setterholm (kneeling) joins family and friends once again for the opening of the state's pheasant season.

**Neuharth is one of more than 900,000 U.S. farmers participating in the Conservation Reserve Program, which gives them annual subsidies to replace some cultivated land with natural cover.**



**KEEPING IT WILD** **Waterfowl decoys float on a lake in central North Dakota, part of the prairie pothole region. Aiming to preserve two million acres of habitat in the Dakotas and Montana, Ducks Unlimited uses hunters' donations to buy permanent easements from local landowners.**

ranching, timbering, fishing—and hunting.

"It starts with managing the land properly," said Turner, who allows paying visitors to hunt for quail, bison, elk, antelope, wild turkey, and other species on his properties. "You need good healthy land for good healthy animals. They need good water, good cover, and good food. If you're missing any one of those three things, you won't have animals. I maintain my ranches with wildlife being the top priority. I am trying to do the smart thing for the environment instead of the dumb thing. I want others to see what can be done with the land—even if they're not billionaires."

Turner has found a way to make hunting pay for conservation. At his Vermejo Park Ranch in New Mexico and Colorado, he allows a few hunters to kill about 200 trophy elk each year—some 2 percent of his 10,000-elk herd. Each hunter pays $10,000, which brings two million dollars in revenues annually. "Now, that's a pretty acceptable figure," said Turner, who uses the income to keep his 600,000-acre property in a relatively wild state, with few fences and with preference given to indigenous plants and wildlife.

Hunters of more modest means contribute to conservation in other ways, giving 280 million dollars annually to organizations such as Pheasants Forever, the Ruffed Grouse Society, the National Wild Turkey Federation, Quail Unlimited, and other nonprofit groups, which sponsor scientific research for particular species and maintain important habitat. Since its formation in 1937, Ducks Unlimited has conserved more than 11 million acres of wetlands and associated

**"IT'S THE HUNTERS WHO KEEP MOST OF THESE SPECIES GOING. THEY PUT IN THE MONEY, AND THEY PUT IN THE HOURS. HUNTERS REALLY CARE ABOUT WHAT HAPPENS."**

**JIM CLAY, SCHOOLTEACHER AND HUNTER**

uplands. Hunters also focus public attention on conservation issues in state legislatures, in Congress, and in the marketplace. When you buy a camouflage camisole ($24.99) from the Ducks Unlimited catalog, a portion of the proceeds goes to conservation projects. If you visit Bozeman, Montana, and buy a pair of Schnee's Pac boots, you will find a tag dangling from the laces, along with a promise that the Rocky Mountain Elk Foundation will receive some of your money for elk conservation projects.

"It's the hunters who keep most of these species going," said Jim Clay, a middle school English teacher, hunter, and maker of turkey calls in Winchester, Virginia. "They put in the money, and they put in the hours. Hunters really care about what happens."

AS A BIRD HUNTER who occasionally shoots a deer for the freezer, I have never shared the big-game hunter's appreciation for horns, antlers, and trophies, which convey an elevated status upon those who keep track of such things. They carry pictures of trophy elk and whitetails in their wallets and speak knowingly about Boone and Crockett Club scores for antler points, rack spreads, and other measurements. It may be that trophy fever is rooted in the aesthetic that prompts me to save a few grouse or woodcock feathers each year—which are beautiful on their own merits and evoke a particular day in the field, when a bird twittered up through the alders, folded in mid-flight, and was brought to hand by Bart, an old Brittany spaniel who still knows his job and does it with style.

Bart and I pile into the car with the first cool days of autumn, heading north, as we've been doing for more than a decade. Even at age 13, he still quivers like a puppy; he knows what's in store, the very thing for which he was bred as a pointing dog. Year after year, we tromp the same moldering orchards, endure the same slashing hawthorn thickets, hear the same old stories from friends in New Brunswick and Maine, and flop in the same seedy hotels along the way. We mourn the dogs that have died since last year and meet the puppies that will replace them. This routine is a reminder that the seasons dance to a cadence as old and reassuring as Ecclesiastes—even older.

Each bird I take from Bart is accepted with a mingling of thanks, a twinge of regret, and a smoothing of earth-colored feathers. When we have enough for a meal, it is cause for ceremony, accompanied by good wine and extravagant praise for Bart, who can no longer hear a word I say but pretends to, knowing this will earn him a nice piece of woodcock or grouse at the end of the show. Such gestures are important in a world where hunting seems increasingly irrelevant and misunderstood.

Well, maybe not so misunderstood. In the rural Virginia county where I live, neighbors drive the roads at night, illegally spotlighting and shooting deer, in and out of season. Just last autumn, while walking on my own land, I found

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*Robert M. Poole, the former executive editor of* NATIONAL GEOGRAPHIC, *is the author of* Explorers House: National Geographic and the World It Made. *He is a contributing editor at* Smithsonian.

**RETURN OF THE NATIVE** Once indigenous to Kentucky and other eastern states, elk were exterminated in the region in the 19th century. With money from the Rocky Mountain Elk Foundation,

they've come back. Now thriving, the wild Kentucky herd numbers 6,500—enough for a limited hunting season. Donna Reinholt of Indiana drew one of 200 tags, bagging a bull last year.

a very young doe that had been shot through the spine, which made her back legs useless; otherwise she was alert, eyeing me, kicking her front legs to get away. I put her out of her misery and ate venison the next few weeks, thinking that there was no reason to compound my neighbor's crime by treating the creature as garbage. Up the road in Shenandoah National Park, authorities recently broke up a ring of hunters who were shooting black bears and selling their gallbladders for the Asian medicine market.

Elsewhere, hunters illegally bait for ducks, kill over their limits, ignore the season, spray houses with bird shot, and argue with landowners who catch them trespassing. Even some people who hunt legally do not hunt ethically, leaving mortally wounded prey to flop around while they pose for photographs, piling up kills they have no intention of eating, treating their quarry as just another commodity.

"When you're hunting," said Grayson Chesser, a Virginia waterfowl guide and decoy carver, "you have to be ethical. You have to come to terms with the impact you have on other creatures. But I'm

**BRUSH BUSTING** **Mike Zagata, executive director of the Ruffed Grouse Society, prospects for birds near Grand Rapids, Minnesota. His organization encourages the thinning of old trees to promote growth of dense young forests that attract birds, deer, and other species.**

afraid we're seeing a new generation of hunters who are disconnected from tradition. Half the time, they don't even know what they're shooting—they're so obsessed with the latest gun, the latest camo pattern. And they think you're some kind of sissy if you don't get your limit."

MORE TYPICAL, perhaps, are the hunters you meet on the wind-whipped grasslands of central Montana, where a local chapter of Pheasants Forever has converted an 800-acre parcel into a haven for pheasants and other wildlife.

"Pheasants need grain and cover," said Tom Stivers, a biologist with the Montana Department of Fish, Wildlife, and Parks who showed me around the Coffee Creek project. The rolling, treeless plains looked well-groomed. Rows of alfalfa, sweet clover, and silver sage hugged the sinuous contours of Coffee Creek, while the surrounding hills bristled with juniper, buffalo berry, chokecherry, and golden currant. In the distance, snow clouds swirled around Square Butte, a landmark anchoring the scene, just as it did in paintings by cowboy artist Charles M. Russell.

"Plenty of food, plenty of cover," Stivers said. "As long as they have those things, they will stick around—even if you're hunting them hard. If you've got the habitat, hunting isn't really a limiting factor if it is properly managed."

During an hour or so of combing the hills, we neither saw nor heard another human, not even the rumble of a distant pickup truck. On one hill, we kicked up a flock of 20 sharp-tailed grouse, saw bald eagles wheeling overhead, and sighted perhaps 50 mule deer bounding toward the horizon. But not a single pheasant.

"So, where are all the pheasants?" I asked.

"Oh, there are plenty around," Stivers said, discreetly toeing the ground with a scuffed boot, calling attention to the hundreds of bird tracks in the snow. After the long hunting season, the birds grow wary of anything on two legs. The brushy, low-lying shelter belts were doing their job, concealing pheasants while providing sanctuary from the harsh Montana winters.

The place also offered a refuge of sorts for people like Craig Roberts, founder of the Pheasants Forever chapter in Lewistown, Montana. In the old days, hunters could grab a shotgun and take to the hills after work with little concern about bumping into other people. But land ownership patterns have changed in recent years,

with old ranches carved up into smaller ones, and new owners saving the hunting rights for themselves or banning the sport altogether.

"Access has become a bigger problem than habitat," Roberts said by phone from his wintering grounds in New Mexico. "The demand for land simply outstrips supply, so that more and more hunters have to pay for access to private lands."

By contrast, the Coffee Creek property is open, free of charge, to anyone who wishes to hunt there, which means that it gets plenty of action—virtually every day of Montana's three-month pheasant season. "We get people from 41 states and one Canadian province," Roberts said. "But that land can stand it. We already had good cover. We just keep adding new shelter belts and grain every year. That brings in the birds. It shows what one little local group can put together."

Meanwhile, back on Coffee Creek, Stivers and I finally jumped one indignant-looking pheasant, loitering near a tractor shed at the center of the property. Neither of us was armed, but the gaudy rooster sprinted off nonetheless, making tracks in the snow and disappearing into heavy brush—there for a second, gone the next, just like Square Butte floating in and out of view on the horizon. Wind rustled the junipers, Square Butte glowed in the soft light, and Stivers offered a sort of benediction: "You come out here for a few hours with your dog. You do some hard walking. It's quiet. You see old Square Butte coming out of the clouds up there, and you get a couple of birds—good food, good exercise, and a good way to reconnect with those people who were here before. They were looking across the hills for wildlife, just like we're doing. We find their arrowheads all the time. They were hunters too."

SOME SCIENTISTS SPECULATE that humans are still programmed for the chase, since our species has been doing that far longer than we have been farming, writing poetry, or marketing stuff by telephone at dinnertime. After emerging on the plains of Africa, our hominin ancestors began hunting more than a million years ago, killing other creatures in order to live.

"We were all hunting until the Neolithic about 10,000 years ago," said Wade Davis, an anthropologist and explorer-in-residence at the National

## SAVING WILDLIFE

### THROUGH HUNTERS' ORGANIZATIONS

Hunters contributed 280 million dollars in 2006 to dozens of groups that devote most of their revenue to conservation. Some of the biggest:

| | REVENUE *(millions of dollars)* | PERCENT SPENT ON CONSERVATION | MEMBERS |
|---|---|---|---|
| Ducks Unlimited | 162.1 | 82 | 774,000 |
| National Wild Turkey Federation | 48.1 | 94 | 583,000 |
| Rocky Mountain Elk Foundation | 28 | 87 | 150,000 |
| Pheasants Forever | 26.8 | 89 | 115,000 |
| Quail Unlimited | 5.7 | 84 | 50,000 |
| Whitetails Unlimited | 5.1 | 77 | 75,000 |
| Ruffed Grouse Society | 2.6 | 93 | 23,000 |

### THROUGH LICENSES AND TAXES

(Latest available annual figures)

STATES

**Hunting and fishing licenses** — $1.22 billion

Helps state wildlife agencies acquire, maintain, and improve fish and wildlife habitat through the North American Wetlands Conservation Act and other programs.

**Excise taxes** on fishing and hunting equipment and motorboat fuels — $616 million

Helps state agencies buy land and improve fish and wildlife habitat through the Federal Aid in Sport Fish and Wildlife Restoration programs.

Licenses and excise taxes make up about **75%** of state wildlife agencies' revenue.

FEDERAL

**Duck stamps** Required of waterfowl hunters age 16 and older — $24 million

Purchases wetland habitat for the National Wildlife Refuge System through the Migratory Bird Conservation Fund. Sales since 1934 exceed $700 million, and 5.2 million acres have been preserved.

SOURCES: U.S. FISH AND WILDLIFE SERVICE; CHARITY NAVIGATOR

**AUCTION FOR HABITAT** **Hunters bid on a stuffed gobbler at the National Wild Turkey Federation convention in Nashville, Tennessee —an event that raised 1.1 million dollars. The organization finances habitat projects that have helped restore the bird in the lower 48 states.**

Geographic Society who has studied traditional hunting cultures from Arctic regions to the Amazon Basin and Oceania. "Every day, you had to kill the thing you loved most, the animals upon which your life was dependent. It was the first mystery—and I would argue the basis of religion, which was an attempt to explain what happens after you die."

In the traditional cultures Davis has studied, the skillful hunter is a respected figure, with a relationship to prey transcending the material world. "There is a strong sense of connection between the people and the prey," he said. "It penetrates every level of the hunt. If you don't respect the prey, if you violate the taboos, then you won't be able to hunt. And if you cannot hunt, you cannot eat. In our own culture, as we've become more urbanized, we've lost this connection with the natural world. The further away we get from the wild, the less we understand it."

They still understand the value of hunting in tiny Gardiner, Montana (population 851), where visitors are welcomed by a sign carved with elk antlers, the Antler Pub and Grill advertises weeknight poker, and a sign at the Yellowstone Village Inn promises: "Hunters Welcome—Elk Stay Free." Thousands of elk graze the hills around town, essential winter range for many in the Yellowstone herd.

This isolated community has been dependent on outdoor enthusiasts since President Theodore Roosevelt, a keen hunter and a founding father of America's conservation movement, helped put Gardiner on the map in 1903. He came to enjoy a few weeks of solitude in Yellowstone National

**FRIENDLY FIRE** Periodic brush fires bring new life to southern pine forests by clearing debris and producing fresh grass, seeds, and other food for insects, quail, and wild turkeys. A land manager

**sets controlled burns on private woodlands near McCormick, South Carolina, where new growth —and new wildlife—will begin to flourish in a matter of weeks.**

Park in April of that year—and to argue the case for conserving forests and bison, elk, and other game species then in decline.

"Every man who appreciates the majesty and beauty of the wilderness and of wild life . . . should strike hands with the far-sighted men who wish to preserve our material resources, in the effort to keep our forests and our game-beasts, game-birds, and game-fish . . . from wanton destruction," he wrote of his Yellowstone trip. Like other sportsmen of his day, Roosevelt was alarmed at the loss of fish and game, and set out as President to do something about it. By the time he was through, he had helped conserve more than 200 million acres in new national parks, bird reservations, national forests, federal game preserves, and other lands.

Barely a century later, Roosevelt would no doubt be pleased to see the herds of elk still lumbering out of the park in January, across the ice-fringed Yellowstone River, and up into their snow-covered winter range around Gardiner.

The temperature was stuck at one degree Fahrenheit, and the stars shone hard and bright at four on the morning of January 7, when Warren Johnson cranked up his Dodge pickup and we went sliding down the Jardine Road toward Gardiner, stopping every few miles to check for elk tracks in the snow. Johnson, a well-regarded outfitter in this part of Montana, is one of those big, self-contained westerners who may speak 500 words in a particularly voluble week. After a few stops, I could stand the silence no longer.

"Any bulls?" I asked.

"Yep," said Johnson.

"Well, how many?"

"Looks like a hundred elk crossed here last night—maybe three or four good bulls among them," Johnson said, studying the tracks with his long-handled flashlight. "They will be going behind that ridge," Johnson said, slowly turning to indicate a shadowy hump against the night sky. "That's where we start today."

Back at Johnson's Hells-A-Roarin' Ranch, we traded the pickup for horses and, as new snow clouds wisped around the moon, we made a slow climb up through the Gallatin National Forest. Johnson led the way, followed by Ron Harris, a pipe fitter from Cashmere, Washington; his hunting buddy, Mike Strutzel, also from Washington; two other Montana guides; and a straggling figure bundled in so many layers that he looked like a horseback version of the Michelin Man. One of the guides was assigned to watch over the Michelin Man, who had to be plucked out of snowdrifts and hoisted into the saddle throughout the morning, for which I was grateful. Strutzel came to root for Ron Harris, the only person in this party of six who was actually hunting.

Harris had drawn one of Montana's rare late-season elk permits in August, borrowed money for the $3,000 trip, and was finally pushing his horse up through the pines in chest-deep powder this morning. At a signal from Johnson, Harris dismounted, kneeled in the snow, and took aim on a bull elk, which we had spotted and outflanked by riding around a ridge. Anticipating the crack of Harris's rifle, I tightened my horse's reins just in time to see Warren Johnson

**THE IRONY IS THAT MANY SPECIES MIGHT NOT SURVIVE AT ALL WERE IT NOT FOR HUNTERS TRYING TO KILL THEM. THE NATION'S 12.5 MILLION HUNTERS HAVE BECOME ESSENTIAL PARTNERS IN WILDLIFE MANAGEMENT.**

wave off the shot. "He was a nice bull," Johnson explained later, "but we'll see a better one."

The next morning, up in the dark and back in the saddle, we took to the mountains again, where a magnificent five-by-six-point elk presented himself to Harris. But just as he squeezed off the shot, the bull stepped out of the way—prompting a clean miss. The elk vanished at a trot, and we rode in uncomfortable silence through the rest of the morning.

On his third day out, after I'd left, Ron Harris got his bull, a 750-pound male in prime condition, with a heavy six-by-six-point rack. "If you've ever seen a grown man cry, you almost would now," Harris told me by phone that day. "I am one happy guy." The big elk rode back to Washington with Harris and Strutzel, who converted it into steaks, chops, and sausage. The bull's head would take a place of honor in Harris's game room.

He has something in common with his European ancestors, who decorated the walls of their

**CULLING DEER** **Bow hunter Michael "Mad Dog" Maddy volunteers in Murrysville, Pennsylvania, to thin the herd. White-tailed deer eat away at suburban plantings, ravage forests, and endanger motorists. Their numbers in the U.S. are estimated to have soared above 25 million.**

Chauvet Cave with exquisite paintings of reindeer, bison, bears, and other revered animals, celebrating their magical power. That was more than 30,000 years ago, yet anthropologist Wade Davis discerns a connection between the paintings and today's hunting trophies: "It's totally connected."

WHATEVER THE SPIRITUAL BOND between hunter and prey, there was no mystery about the link between hunting and prosperity in a town like Gardiner, which relies upon Yellowstone elk and the hunters who follow them to carry the community through winter. When

**KILLING FIELDS** In a blind surrounded by decoys, Tony Rushing takes aim at migrating snow geese near Hamburg, Iowa. With their numbers exploding, geese crowd the Canadian tundra in spring and

summer, threatening to devour their own nesting grounds. Under a federal conservation order that seeks to reduce the flock to sustainable levels, Iowa allows hunters 20 geese a day for three months.

**RECOVERY** **In Mexico's Vizcaíno Biosphere Reserve, guides prepare a rare desert bighorn sheep for trophy mounting. The Baja California herd has doubled to some 400 since 1997, when the Foundation for North American Wild Sheep began auctioning permits for hunting here.**

the elk were thriving, so was Don Maroney, the bearded, peppery man who presides at the Two Bit Saloon on Highway 89, where the dim light would make a Chauvet cave painter feel at home.

"It's sad," Maroney said, looking around the empty bar on a winter afternoon. "When the herd numbers were up, we'd have 3,000 hunters in town in one season. They'd come in for a beer, stay in a motel, get gasoline, and spend money. Those days are gone." It seemed to be true. Out on the highway, red "Vacancy" signs flickered at every motel in town, the parking lots were empty, and one of Gardiner's three gas stations was up for sale. Restaurants were deserted. A few bleary-eyed hunters could be seen rattling through town, but their numbers had fallen, mirroring a drop in the size of the Yellowstone elk herd. Since its recent peak of 19,045 animals in 1994, the number of elk had dropped to just 9,215 in 2006.

At Gardiner's gathering places, the decline was blamed on hunters—not those bipeds in orange vests but the four-legged ones in fur coats, namely gray wolves. These superbly effective predators, reintroduced into Yellowstone National Park between 1995 and 1997, were flourishing. Fueled by an abundance of elk protein, their population had skyrocketed from a founding colony of 41 wolves to some 380 today.

"Those wolves are hunting all the time—24/7—with no checks on them," said Don Laubach, who sells elk calls and hunting equipment around the corner from the Two Bit Saloon. "No wonder the elk are down."

What to do?

"Nobody wants the wolves to be eliminated," Laubach said. "Just control them—they need predators too."

They might have them before long. Federal officials recently proposed that the wolves be removed from the endangered species list in Montana and Idaho, which could eventually allow for wolf hunting outside Yellowstone National Park. Fewer wolves could mean more elk and a comeback for hunting around Gardiner.

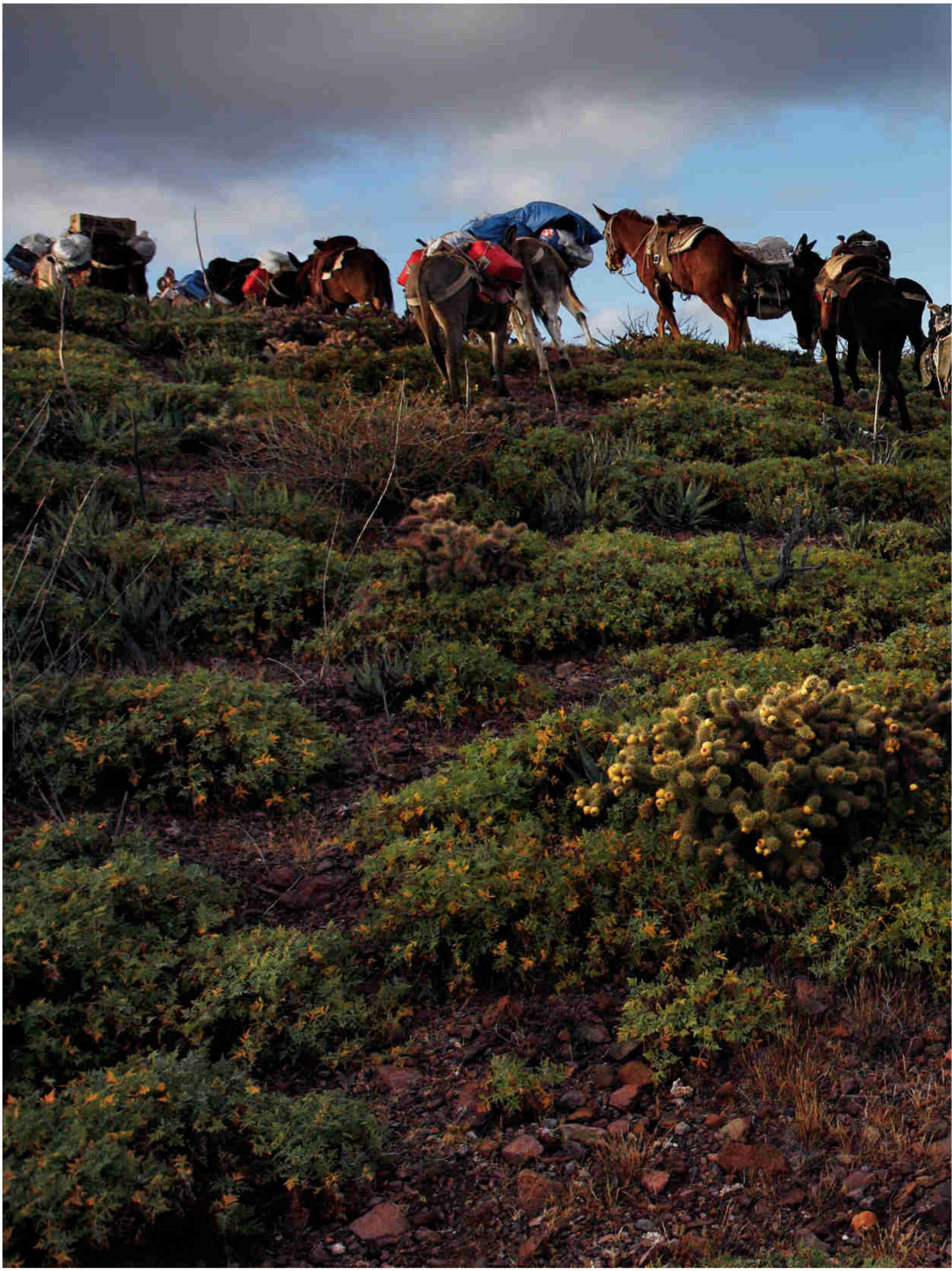
Until then, said Tom Lemke, the state biologist who watches over the north Yellowstone region, the Montana Department of Fish, Wildlife, and Parks will recommend only a handful of late-season tags, perhaps 160 for the Gardiner region.

"If the elk numbers go up and we can keep things in balance," Lemke said, "we'll issue more permits. We understand why hunters want more tags—but the elk herd is about where it

ought to be, according to our management plan."

How many wolves could the Yellowstone system support? In the heated debate surrounding that question, it was easy to forget the time, back in the 1990s, when the state had recruited hunters to reduce the elk herd, which was thought to be too large. The big ungulates were starving, and biologists worried that they were overgrazing the resource. Now the wolves were ascendant, the elk down, and the local populace restive. For wildlife managers like Lemke, keeping predator and prey in balance is increasingly tricky.

HUMAN POPULATION GROWS. Habitat shrinks. The long, slow march from rural to urban living began when the Civil War ended in 1865. Two gentlemen of my acquaintance were on the front end of this transition from farm to town: They were Talmadge Spurgeon Teague and James Augustus Poole, who laid aside their plows and headed for North Carolina villages as the 20th century began. They took their shotguns to town and made regular forays back into the country for hunting. Both were respected for their gunning abilities—especially T. S. Teague,



**ECONOMIC INCENTIVE** Acting as guides and wranglers, local people from the Vizcaíno reserve set out with foreign trophy hunters, who spend as much as $82,500 each for a chance at a bighorn.

**Money from such hunts has helped build a new clinic, school, and water projects in the community —encouraging villagers to keep their region's wildlife healthy and its habitat secure.**

who would invite the preacher on Friday for a quail dinner on Sunday, confident that he could find the birds Saturday afternoon. He always delivered—at least that is how my mother remembers my grandfather. From him, I inherited a love for the life afield; from my other grandfather, it was a love for dogs—and his battered 12-gauge Ithaca shotgun.

That old double-barrel is something of a relic, like the declining numbers of Americans who go out to hunt each year. "We're the endangered species," said Steve Del Rossi, a New Jersey dog breeder and hunting companion, with whom I often share a duck blind. On a recent December morning, we found ourselves shivering by Maryland's Chester River as the sun strained behind sooty clouds and thousands of Canada geese honked overhead in long, noisy formations. Looking down the bench in our blind, it occurred to me that Del Rossi was right: I counted four other white guys with red noses poking from their head-to-toe camouflage, all overfed and over 50, all from hunting families with no understudies to follow them.

In recent decades, the number of hunters has been dropping. According to U.S. Census Bureau data, there were 14.1 million hunters in 1991, 13 million in 2001, and 12.5 million in 2006, which means that they now make up a mere 5 percent of the adult population. Younger hunters are entering the field but not in sufficient number to replace the old ones, who die off or retire their guns for other pursuits. In recent national surveys, the niche formerly occupied by hunters and anglers is being filled by a new species of outdoor enthusiast called "wildlife watching participants" by the U.S. Fish and Wildlife Service. This new group—including nature photographers, traveling birders, and stay-at-homes with bird feeders—accounts for 71 million people, more than 30 percent of the adult population.

It is too soon to know whether the wildlife-watchers will bring enough money and enthusiasm to the outdoors to keep game species flourishing, much less to bankroll the nation's state fish and wildlife agencies, which depend on hunting and fishing revenues for most of their funds. "It's something we're very concerned about," said Ed Parker, President of the Association of Fish and Wildlife Agencies. "We think about it all the time."

So does Ted Turner. "The quality hunting has already moved to private land," he said, predicting that this trend will continue as population grows. "The United States is expected to have a population of over 400 million by 2050. That doesn't leave much room for the animals. It will get more expensive for hunters."

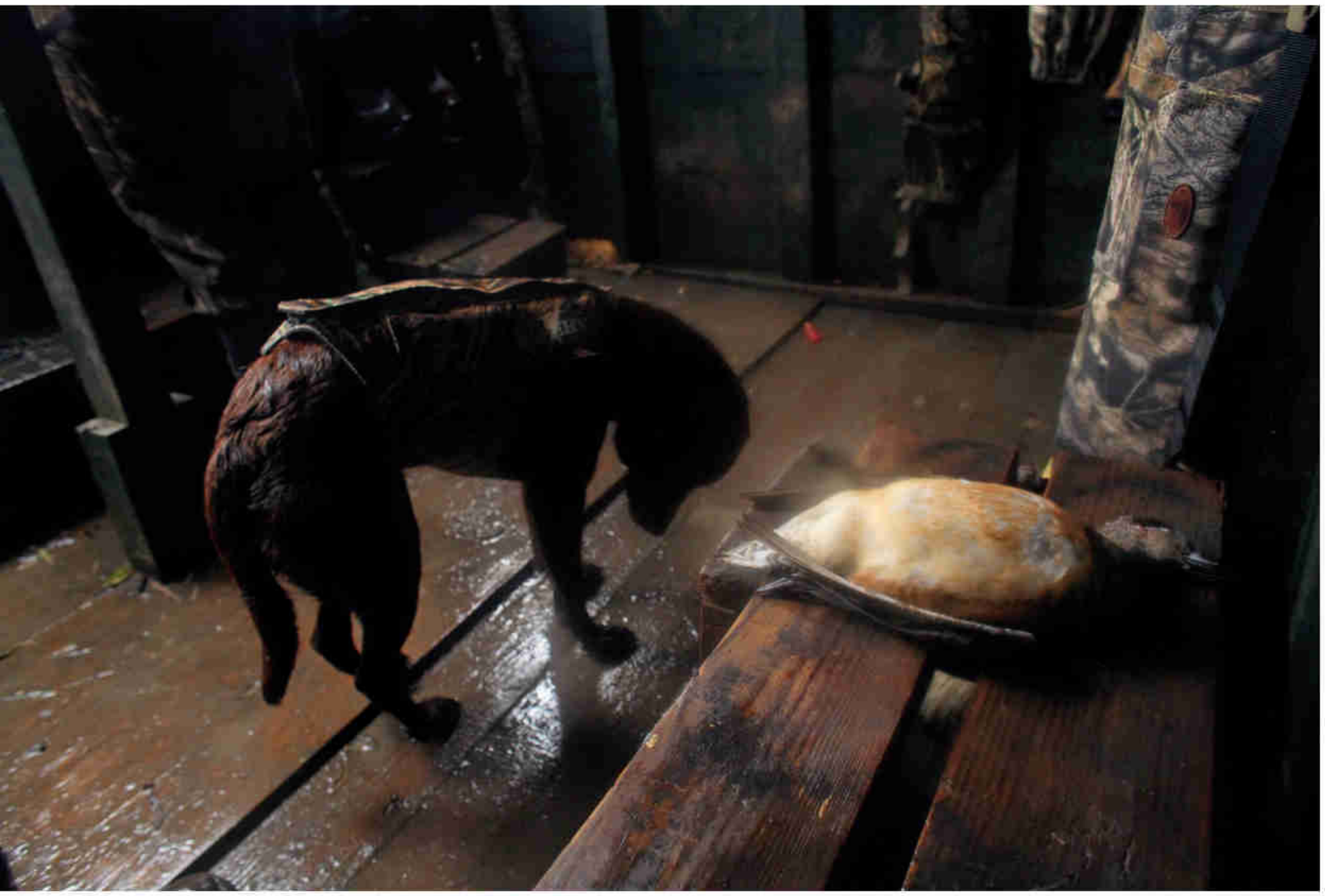
**"AS WE'VE BECOME MORE URBANIZED, WE'VE LOST THIS CONNECTION WITH THE NATURAL WORLD. THE FURTHER AWAY WE GET FROM THE WILD, THE LESS WE UNDERSTAND IT."**

**WADE DAVIS, ANTHROPOLOGIST**

OLD HUNTERS MELLOW, their bloodlust fading with the years. They still hunt, but not as hard, maybe because they simply have less energy or because they have a growing sympathy for their prey.

"I killed too many ducks when I was young," admitted Thomas J. O'Connor III, a Suffolk,

**Preserving Game** See hunters in the field as well as evidence of their conservation efforts in our Photo Gallery at **ngm.com**.



**ANCIENT RITUAL** **Hunters, dog, and prey share an Arkansas duck blind. Hunting—an essential part of human endeavor since prehistory—remains so for many, who pay homage to ancestors and reenact the old struggle for survival each time they take to the field.**

Virginia, peanut broker who is engaged in a sort of penance now. In recent years, O'Connor has been painstakingly restoring critical waterfowl habitat on Virginia's Eastern Shore, where wintering masses of ducks and geese find food and shelter on his 750 acres. Much of that land will be preserved in scenic easements, so that it will be shielded from the development rapidly colonizing the fields and woods around Cape Charles.

O'Connor showed me around a seaside farm wreathed by salt marsh and fragrant with pine woods. We sent hundreds of ducks flying at our approach, mostly wood ducks and teal, whistling up from the shallow ponds O'Connor has carved for them out of the black, sandy soil. "I'm proud to say that I never took a dime from Ducks Unlimited—although I took plenty of advice from them," O'Connor said.

Watching clouds of ducks circling overhead, he suddenly cracked a smile. The birds had banked sharply, changed direction, and come our way again, splashing down practically at our feet. "They can't stay away," he said. "They know they're safe here, just like those teal you see over there." He pointed to a knot of the fast-flying, chunky little birds. "Look. See them?"

O'Connor stood on his tiptoes and watched the teal disappear over the trees and off toward the north, where they would be breeding soon.

He doesn't hunt many teal these days.

Why not?

"I got so I like having them around too much." □

# Raising Heaven

Nearly two decades after its launch, the Hubble Space Telescope beams home new revelations about the life and death of stars and the nature of our expanding universe.

Trailing brilliant streamers of gas, dust, and stars, the Antennae galaxies collide in the sharpest view yet of this cosmic pas de deux.

NASA/EUROPEAN SPACE AGENCY (ESA)/BRADLEY WHITMORE, SPACE TELESCOPE SCIENCE INSTITUTE (STSCI)/
HUBBLE HERITAGE TEAM (HHT)

In the central region of the Carina Nebula 7,500 light-years from Earth, stars are born and die in a violent inferno of stellar winds and ultra-violet radiation. The bright oval spot at center left is Eta Carinae, one of the most massive known stars in the Milky Way, thought to be on the verge of erupting into a gigantic supernova.

NASA/ESA/NATHAN SMITH, UNIVERSITY OF CALIFORNIA, BERKELEY/HHT

By TIMOTHY FERRIS

## You can see it sometimes,

if you're out in temperate latitudes on a clear night at dusk or before dawn, when slanting sunlight glints off satellites 300 miles high—a dot of light, no brighter than an average star, trudging across the sky in a state of seeming preoccupation like that of the rabbit in Alice's Wonderland, the rippling of Earth's atmosphere (the very distortions that it was designed to rise above) making its smooth, ceaseless fall look halting and perturbed. Which pretty much describes its early career: Repeatedly delayed, then lofted into orbit only to prove myopic, repaired by one space shuttle crew, then improved by others, the Hubble Space Telescope has become the world's most popular scientific instrument, one that has been seen, and seen *through,* by more people than any before. Scientists feast on its data, while its beautiful images of star clusters, nebulae, and galaxies have made its name—after Edwin Hubble, discoverer of the expansion of the universe—almost as well-known as Google.

It's curiously appropriate that an unmanned telescope should emerge as a symbol of science, since it was instruments generally—and telescopes in particular—that jumpstarted the scientific revolution. We tend to think of science in terms of great minds conjuring big ideas (an image that Edwin Hubble himself encouraged, at least when it came to his own research), but that paradigm is largely a holdover from prescientific days, when knowledge was sought principally in philosophers' books. In science, instruments can trump arguments. The disinterested verdict of Galileo's telescope did more than Galileo's arguments to lay bare the shortcomings of the regnant Earth-centered model of the cosmos, and Newton's mechanics endured less for their indubitable elegance than for their being able to predict what astronomers would see through their telescopes. Galileo's contemporary Johannes Kepler, whom Immanuel Kant called "the most acute thinker ever born," was quick to grasp that straightforward observations using scientific instruments could sweep away centuries of intelligent but ignorant discourse. Although he was a mathematical theorist who never owned a telescope, Kepler celebrated Galileo's innovation in an ode, addressing the telescope as, "You much knowing tube, more precious than any scepter."

Young stars blast a hole through the nearby Small Magellanic Cloud (left). Like other images from Hubble (above), this one is a composite of multiple exposures taken through filters that record different wavelengths of light. Colors are added during processing.

Hubble is Galileo's telescope flung into a Keplerian orbit, and if these two early scientists came back to life today, I expect they would be impressed less by its technological sophistication than by its potential to bring things to light that challenge old ideas—and to publish them on the Internet, science having always been about making knowledge available. That was certainly the attitude of Lyman Spitzer, Jr., the astrophysicist and alpinist who proposed putting a

LEFT: NASA/ESA/ANTONELLA NOTA, STSCI, AND LYNN CARLSON, JOHNS HOPKINS UNIVERSITY (JHU)/HHT. ABOVE: NASA

The man behind Hubble dreamed of a telescope that would "uncover new phenomena not yet imagined, and perhaps **modify profoundly our basic concepts of space and time."**

large astronomical telescope in orbit in 1946, nearly a half century before Hubble was launched and long before many of the innovations it relies upon—microprocessors, digital imaging and communications systems, the space shuttle—yet existed. Spitzer stressed that it would serve not just to test and refine existing ideas, but also to spark entirely new ones. "The chief contribution of such a radically new and more powerful instrument," he predicted, "would be, not to supplement our present ideas of the universe we live in, but rather to uncover new phenomena not yet imagined, and perhaps to modify profoundly our basic concepts of space and time."

## Selling a billion-dollar project

with hand-waving promises that it would alter our basic conceptions of the universe could not have been easy. But Spitzer persisted, lobbying Congress for years while reassuring his fellow scientists that the job could be done without underfunding traditional ground-based astronomy. Ultimately he prevailed, lived to see Hubble fly, and was working in his Princeton office with Hubble data on March 31, 1997, hours before he died suddenly at home that night, at the age of 82. His dream, "that a large space telescope would revolutionize astronomy and might well be launched in my lifetime," had come true. His prophecy that it might alter our conceptions of space and time was fulfilled as well—in ways far more remarkable than anyone could have anticipated.

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*Timothy Ferris is the author of* Coming of Age in the Milky Way, The Whole Shebang, *and other works. A film based on his latest book,* Seeing in the Dark, *premiered in September on PBS.*

Before that happened, however, the space telescope did help scientists test and verify many existing astronomical theories. They used Hubble to follow the string of impacts —each more powerful than all this world's combined nuclear warheads—of the disintegrating comet Shoemaker-Levy 9 into the upper atmosphere of the giant planet Jupiter in 1994, a sobering spectacle that helped build a political consensus that NASA ought to inventory asteroids that might one day strike Earth (an effort that is itself threatened by budget constraints, even though most of the potentially dangerous asteroids remain uncharted). Astronomers produced striking images showing the astonishing and unique beauty of planetary nebulae—the shells of gas ejected by unstable, dying stars—which continue to refine astrophysical accounts of how stars evolve in the late stages of their colorful careers. They captured protoplanetary disks in the Orion Nebula and other star-forming regions, confirming that planets begin as disks of dust and gas, as had been theorized. They discovered several of the now more than 200 known planets orbiting other stars and obtained a spectrum for one of them, the first to show the atmospheric composition of an extrasolar planet. They verified the existence of black holes squatting at the centers of galaxies and nailed down a theoretical link between such black holes and the brilliant beacons called quasars. They confirmed that the mysterious high-energy flashes of light called gamma-ray bursts arrive from all over the universe, and that one class of bursts results from the implosion of massive stars.

But the strangest and least expected discovery, the one that really would "modify

Astronomers were astonished to find that
**cosmic expansion is not slowing down at all:**
It is speeding up.

profoundly our basic concepts of space and time" as Spitzer had predicted, came the year after he died.

Two teams of astronomers were using Hubble to investigate supernovae—exploding stars—in galaxies long ago and far away. Their prey was a particular class of supernovae whose intrinsic brightness makes them suitable "standard candles" to help determine the change in the rate of the universe's expansion since light left the distant explosions. They were expecting to find that the rate of expansion has slowed over the eons. The idea was that cosmic expansion ought to be braked by the combined gravitational attraction exerted by all the galaxies on one another—in much the same way that a ball, thrown into the air, is slowed down by Earth's gravity. If the cosmic deceleration rate was greater than a certain quantity, the universe would eventually stop expanding and collapse, like a ball falling back to Earth; if lower, the universe was destined to expand forever.

Instead, the astronomers were astonished to find that cosmic expansion is not slowing down at all: It is speeding up. What's more, this unheralded acceleration has been going on for the past five billion years. It is as if a ball, thrown into the air, at first slowed but then sped up and simply flew away. No natural force on Earth can do such a thing—and none in the known universe could be accelerating the cosmic expansion rate. Nor is the newly discovered force particularly subtle: Taking to heart Einstein's $E=mc^2$—that energy and matter are two sides of the same coin—scientists calculate that the new force comprises 70 percent of all the matter and energy in the universe.

Physicists have taken to calling this unknown force dark energy. But as University of Chicago cosmologist Rocky Kolb says, "Naming is not explaining," and nobody yet knows what dark energy actually is.

It may well be that dark energy is inherent to space itself. Physicists had long suspected that such a "vacuum energy" must exist, since quantum fields, which contain energy, permeate even the emptiest voids out between the galaxies. Yet when physicists calculate the amount of energy in the vacuum, they get absurdly large results, ranging from infinite ("That can't be right," Nobel laureate physicist Steven Weinberg mused) to zillions of times more than is required even to account for the mighty force of dark energy. The disparity troubles them; Weinberg calls it "the worst failure of an order-of-magnitude estimate in the history of science." Clearly, something is wrong with either the observations (but no error has yet been found, in many ongoing studies with Hubble and other telescopes) or with the consensus models of physics and cosmology, which for all their flaws stand as one of the grandest attainments of modern science.

Fortunately, knotty problems often prove to be gateways to scientific breakthroughs. Knowing this, the cleverest scientists are more attracted to vexing questions than to comforting answers. (Physicist Niels Bohr, confronted with one such puzzler, reportedly exclaimed, "How wonderful that we have met with a paradox. Now we have some hope

**Hubble's History** Relive the high-flying telescope's 17 years of drama and discovery in a time line at **ngm.com.**

The next time someone wonders aloud what use it is to spend billions on space telescopes when we have "problems here at home," the answer may be that **they help us understand just what and where home is.**

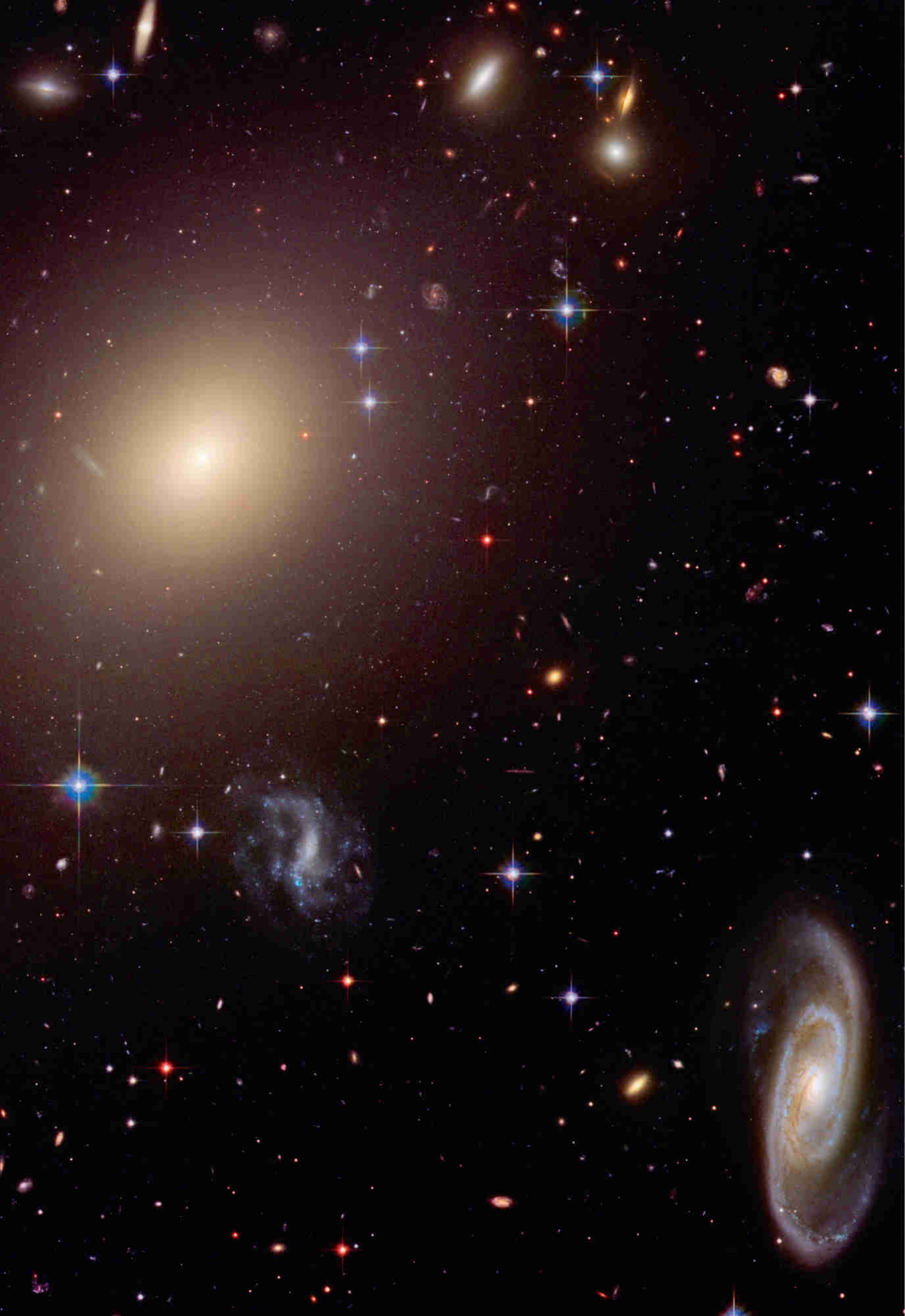
of making progress.") But where might the dark-energy riddle lead?

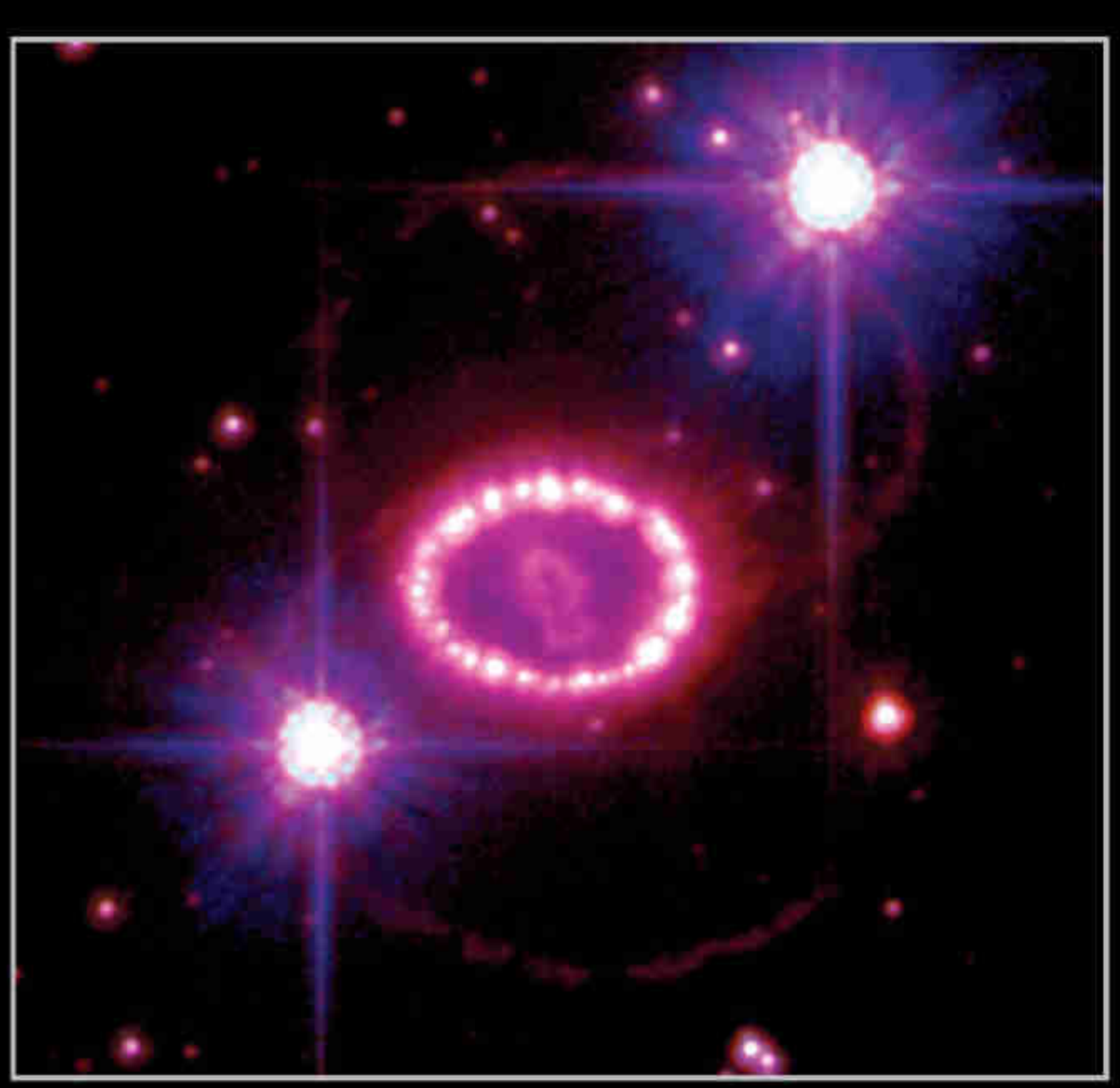
Surveying the whole panoply of physics, from quasars imaged by Hubble near the edge of the observable universe to the subatomic realms probed by particle accelerators, one increasingly gets the sense that science has as yet detected only the tip of an iceberg. Consider the question of dimensionality: On how many dimensions is the universe built? Newton got by with just the three dimensions of familiar, everyday space. Einstein improved on Newton's accuracy by adding time as a fourth dimension: His gravitational fields bend space within four-dimensional space-time. But gravitation is only one of the many fields that, as Weinberg notes, pervade the vacuum of space. If you're trying to write a unified theory of all the known particles and fields, you may find yourself working in a dozen or more dimensions. And for all we know there are multitudes of as yet undetected particles, each with its own field, implying still more dimensions.

Are these dimensions real, or—as philosophers came to consider Ptolemy's Earth-centered model of the universe—just a handy way of calculating? Increasingly, physicists suspect that they are real. If so, the perceived universe is but a glimmer on the surface of something much larger and more complex, and the known laws of nature are not bedrock but a kind of weather, like the clouds that form over mountain peaks. Dark energy may offer a glimpse of the mountain—or iceberg—beneath. So the next time someone wonders aloud what use it is to spend billions on Hubble and the other space telescopes when we have "problems here at home," the answer may be that their use is to help us understand just what home is, and where it abides in the wider and wilder landscape.

**Hubble is getting old.** The next shuttle service mission to upgrade and repair it—scheduled for late next year—may be the last. Fortunately it's not alone up there. Its peers include the Spitzer Space Telescope, which detects long-wavelength infrared light invisible from the surface of Earth; the Chandra X-ray Observatory, which probes the short-wavelength part of the spectrum; and little Swift, a satellite that pinpoints short-duration, high-energy gamma-ray bursts and instantly emails word of them to professional and amateur astronomers around the world. None can do all that Hubble does, but coming up is the genuinely gigantic James Webb Space Telescope: Scheduled for launch in 2013 into an orbit a million miles high, Webb will gather infrared light with a mirror over 21 feet in diameter, stylishly screened from sunlight by an umbrella the size of a tennis court. Together with a growing network of ground-based telescopes and detectors, the space observatories are producing floods of astronomical data, at a constantly increasing rate. They promise, as Lyman Spitzer noted back in 1946, to alter not only what we know, but how we learn.

A giant elliptical galaxy surrounded by an aura of star clusters dominates this deep view from Hubble in the direction of the constellation Centaurus. As the universe expands, its countless galaxies are speeding away from each other at a rate accelerated by a mysterious force called dark energy.





# Dying Stars

Exploding stars, such as supernova 1987A (above), blast out dust and gas, spreading elements that will one day form new stars and planets. Here, a shock wave generated by the giant star's explosion slams into a ring of gas, causing regions of it to glow. The Cat's Eye Nebula (right) formed less violently, as an expiring sunlike star ejected spherical layers of gas at regular intervals, like ripples from a stone cast on a cosmic pond.

ABOVE: NASA/ESA/ROBERT KIRSHNER AND PETER CHALLIS, HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS. RIGHT: NASA/ESA/ROMANO CORRADI, ISAAC NEWTON GROUP OF TELESCOPES AND ZLATON TSVETANOV, JHU/HHT

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# Distant Echoes

In January 2002 an unexplained burst of light equal in brightness to 600,000 suns issued from a star in the constellation Monoceros. The event produced a series of "light echoes," as radiance from the flare-up ricocheted off surrounding clouds of dust. By last year the echoes were fading around the cool red star (right) responsible for the bizarre spectacle. □



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# HOW TO HELP

REMEMBER THIS, PAGE 32 **Memory Boosters** Keep this in mind: Already some five million Americans have Alzheimer's disease, a figure set to triple by 2050 as the U.S. population ages. The result is a huge push to aid the aging brain. Many studies seem to link both mental and physical exercise to a well-oiled memory and less severe age-related decline. But proving cause and effect is hard. People with better brainpower may simply be more active, and some scientists warn that the evidence is slim-to-none in favor of individuals being able to control mental destiny. Still, some actions may be worth the effort.

■ **Stress signals** New research supports the long-held belief that distress and anxiety are bad for the brain. A recent report links chronic stress with a mild form of cognitive impairment that can be a precursor to Alzheimer's disease.

■ **Mind games** Brainteasers have not been proven to fend off dementia. Yet scientists say puzzle away —anything that takes you out of your normal range of thinking (or lightens your mood) can't hurt. Reading, writing, and arithmetic are options for puzzle haters.

■ **Give it a rest** "Poor sleep before or after learning makes it hard to encode new memories," says Harvard neurophysiologist Robert Stickgold. Data suggest a good night's sleep improves motor memory up to 30 percent after a lesson (e.g., piano). Leaving six hours between pursuits helps keep one skill from crowding out another.

■ **Help your heart** Your brain will likely benefit, too, from a healthy diet (antioxidant-rich foods like blueberries may protect brain cells, aiding memory), regular exercise, and possibly light use of alcohol (a new study indicates a daily glass might slow dementia).

■ **Cheat** Keep lists, jot reminders, repeat names aloud. And rely on others. "I just ask my wife," says Johns Hopkins neurologist Barry Gordon. "She remembers 99 percent of everything. She's a perfect memory aid."

PHOTO: REBECCA HALE, NGS STAFF


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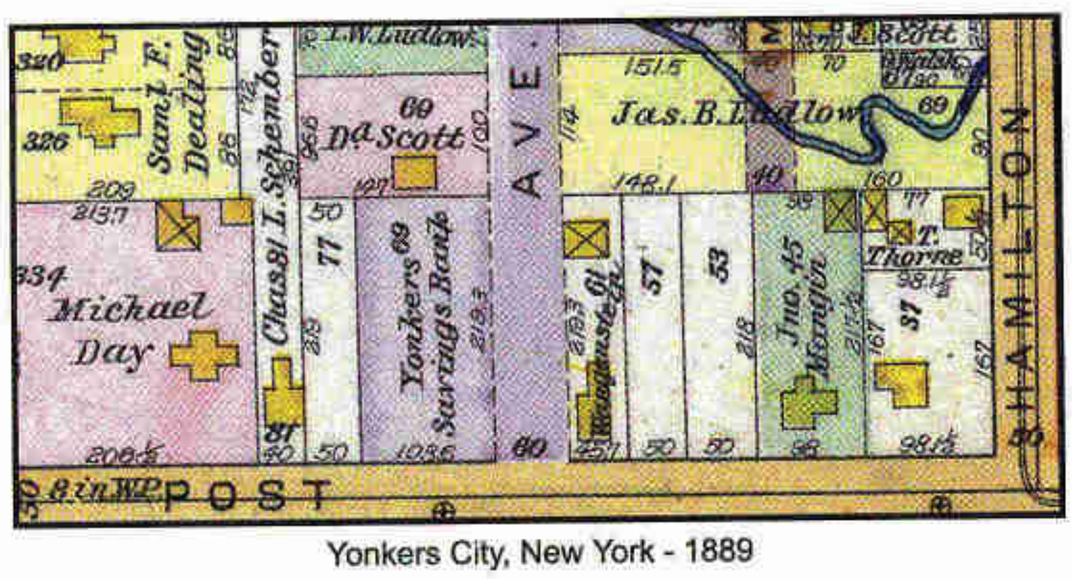


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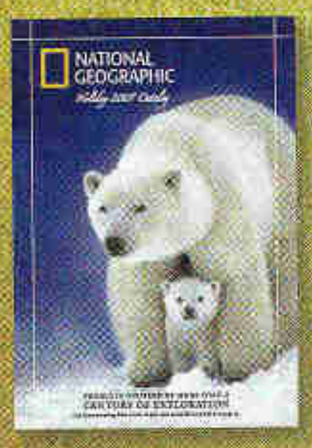


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To find out how to make a donation directly to America's Second Harvest or learn more about the auction, go to *www.woodbridgewines.com.*

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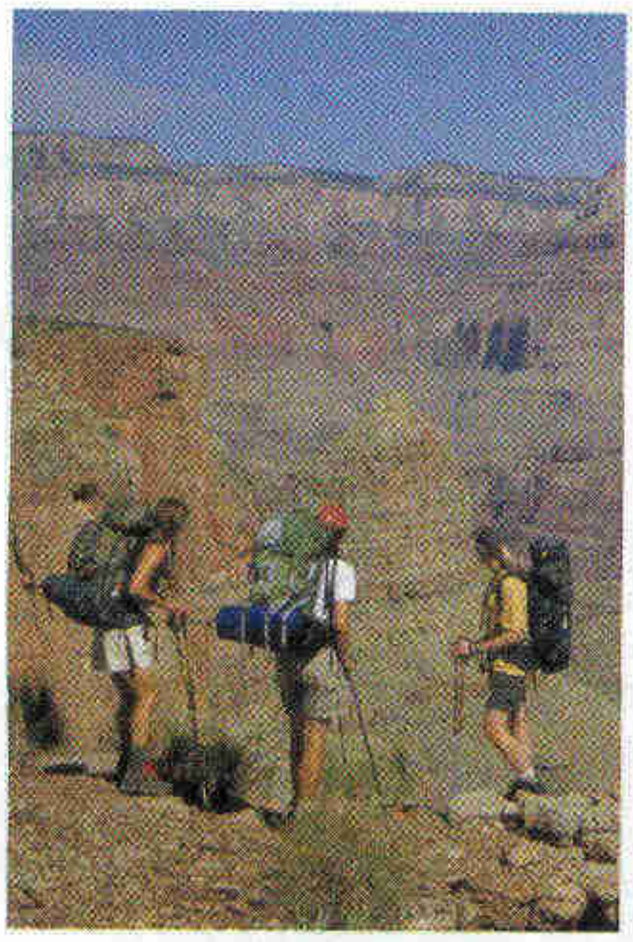

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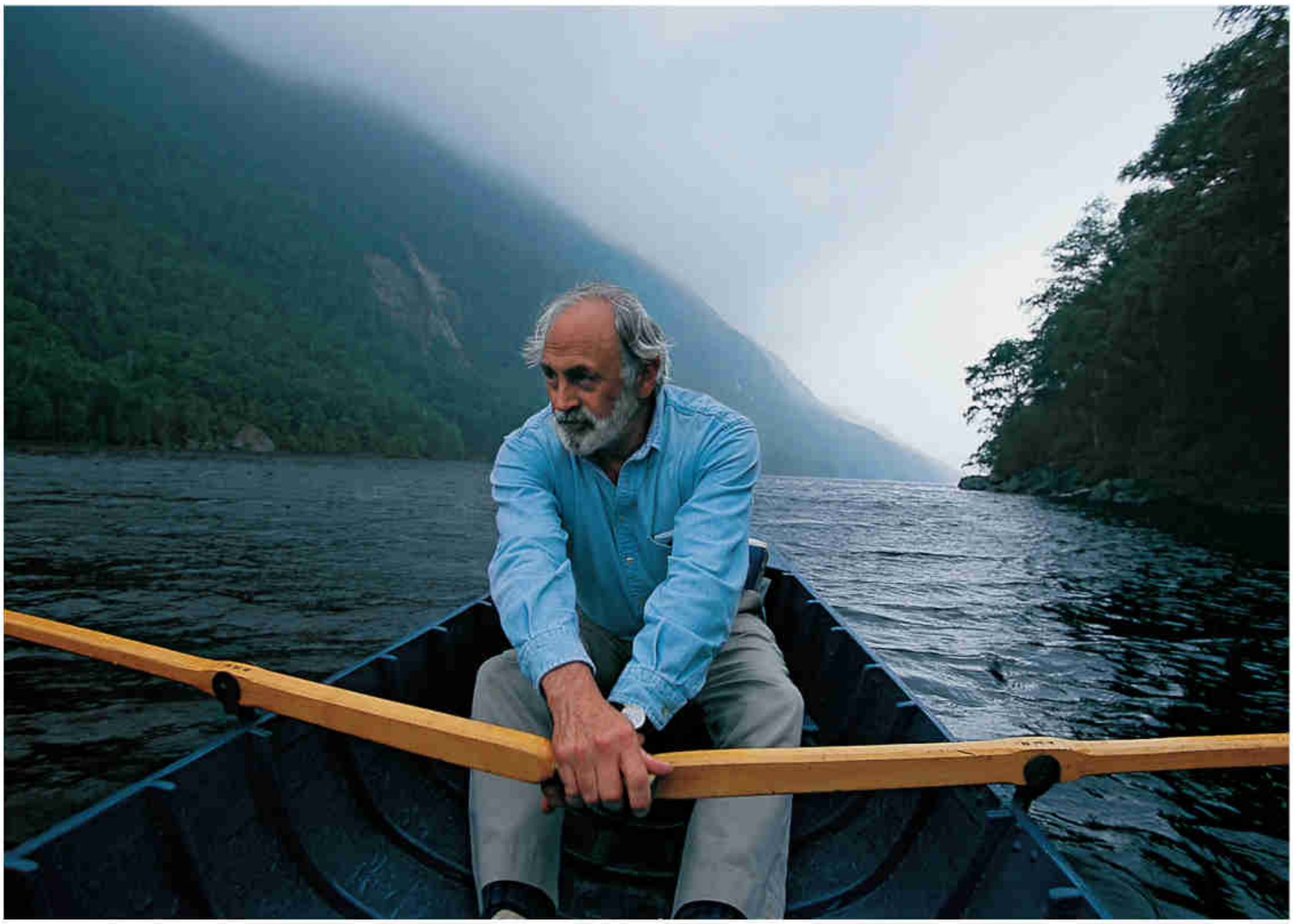


John Mitchell enjoys Lower Ausable Lake in New York's Adirondack Mountains.

IN MEMORIAM **Ode to Mitch** For 14 years he inspired us with his stories, his passion, and his curmudgeonly good humor—reminding us that fun and wild, untamed places are critical elixirs in life. In July John G. "Mitch" Mitchell, our retired senior editor for the environment, passed on to a wild place of his own.

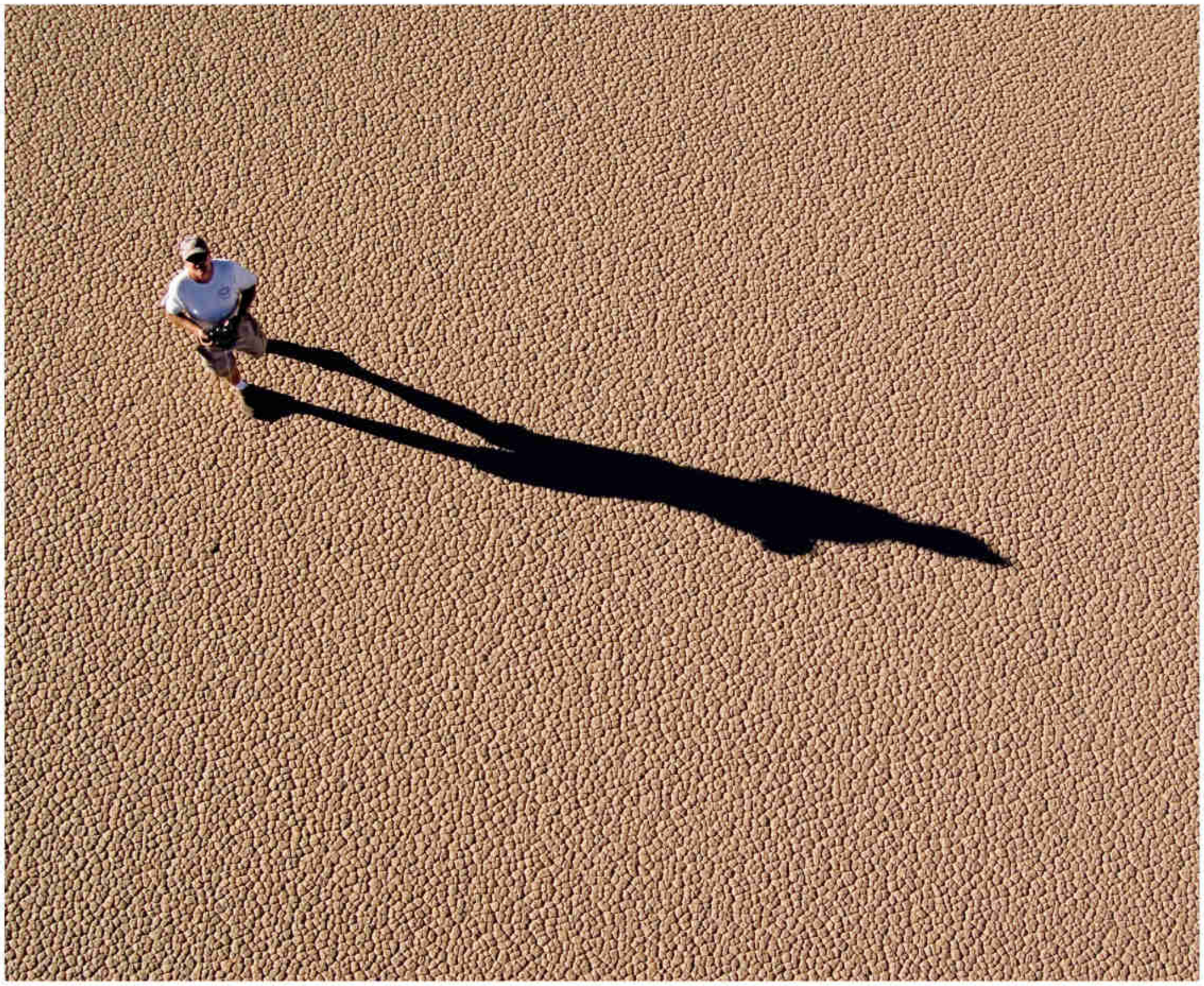
In 23 articles for NATIONAL GEOGRAPHIC, his words danced across our pages like mayflies on a mountain stream, celebrating pristine American landscapes and calling to task those who would defile them. He ruffled some feathers by his coverage of major environmental controversies. But Mitch felt it was the duty of this magazine to inform readers about the issues that affect the natural world. He accomplished that aim with skillful editing, powerful reporting, and eloquent prose. The great loves of his life were his wife, Alison, his daughters Kate and Pam, and the rugged High Peaks area of the Adirondacks: "the center of gravity on which we balanced the worth of each passing year." He'd often watch the sun set over Mount Colvin—named for the Adirondack Park's founder—and pay his respects to another who fought long and hard for nature. He described the scene in a 1998 article: "A sliver of moon can be seen in the sky above Mount Colvin, almost touching it. Wish *I* could."

Now we hope he can. Godspeed, Mitch.



PHOTO: MARIA STENZEL, NATIONAL GEOGRAPHIC IMAGE COLLECTION

# INSIDE GEOGRAPHIC



**ON ASSIGNMENT Down in the Valley** Photographer Michael Melford had a great idea: To get great overhead views of Death Valley, he and his assistant, Jim Day, would rig a camera to a kite. Once they arrived, though, Melford found "there are two kinds of wind conditions in Death Valley: blowing like crazy, and none at all." One near-breezeless morning, Day had to dash across the desert at top speed before he finally got the kite-cam aloft. It flew long enough for Melford to snap this self-portrait (above) via remote control.

**NG PARTNERS Creatures of Climate** Alison Richards and David Malakoff (left) like to say they see the world through "climate-colored glasses." The editors of NPR's *Climate Connections* project are dispatching staff to report on rising seas, unpredictable monsoons, and prolonged drought. Their goal is to find the human stories behind the weather: "How people affect climate and how climate affects people," says Richards. Their 200-plus NPR stories will also look at possible solutions. "Technology got us into this fix," says Malakoff. The question is: Can it get us out of it?

CLIMATE CONNECTIONS
From NPR and National Geographic

PHOTOS: MICHAEL MELFORD AND JIM DAY (TOP); NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN

■ **WORLD EXCLUSIVE:** These are the only known photos capturing the early morning secured delivery of the U.S. Government's new Presidential Dollar Coins for the public unveiling in New York City. Now, the World Reserve is releasing its hoard of the never-before-seen Ballistic Rolls to the general public. You can't get these massive crystal clear Ballistic Rolls from the U.S. Gov't, from the Federal Reserve or from any local bank. Only those who call the Hotline at 1-800-239-3675 and beat the 7 day order deadline can get them.

■ **PUBLIC RELEASE BEGINS:** These are the Ballistic Rolls in the heavy 'Vault Bricks' that everyone is trying to get. They look and feel like heavy solid bars of .999 pure gold.

# Going, Going, Gone

*Free coins are being handed out for the next 7 days to all who cover the $98 vault release fee for never before seen mammoth 'Ballistic Rolls' of new U.S. Gov't dollar coins*

**By SHAWN OYLER**
UNIVERSAL MEDIA SYNDICATE

(UMS) - It's like a run on the banks. The phones just keep ringing off the hook.

For the next 7 days the public is actually getting never-before-seen Ballistic Rolls of the U.S. Government's dazzling new Presidential Dollar Coins.

"The mammoth Ballistic Rolls captured in these world exclusive photos are being handed over to everyone who calls the National Order Hotline beginning at 8:30 a.m. this morning and those who beat the order deadline are actually getting a free coin with each roll," confirmed Timothy Milton, Chief of Coin Operations for the private World Reserve Monetary Exchange.

The U.S. Gov't barely got started minting these new coins and by law were required to stop production forever. There will never be any more.

"First issue coins like these are highly sought after, but we've never seen anything like these sealed Ballistic Rolls being put into the public's hands direct from the private vaults of the World Reserve. Coin values always fluctuate and there are never any guarantees, but uncirculated Eisenhower Dollar coins as recent as 1973 have already increased in value by an astonishing 1,200 percent," Milton said.

"So just imagine what these gigantic fifty coin rolls of new Presidential Dollar Coins could bring someday. These are not ordinary commercial bankrolls. You can't get these Ballistic Rolls from the U.S. Gov't, the Federal Reserve or any local bank. You just can't find these anywhere because they remain sealed in the crystal clear Vault Tubes that show off the coins' edge markings," he said.

Each sealed Vault Tube is then encased in its own gold foil Vault Brick to preserve the coins' radiant, four metal alloy in brilliant never-circulated condition.

And here's the best part. "We are releasing the entire hoard of these sealed Ballistic Rolls from our vaults in the Vault Bricks for just the $98 fee for each. They are so heavy they feel like solid bars of .999 pure gold. So be careful, you may need both hands to pick them up," he said.

"Remember, these coins have never been in the hands of the public. Never-circulated coins are among those most likely to increase in value," said Milton.

You would expect that these

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Vault Bricks of never-circulated Ballistic Rolls would never leave the vault. But now, you can show them off like a diamond ring or a brand new car. You just won't believe the expression on people's faces when you hand them one of these. It's like you just gave them a Million Dollars.

"We can't stop people from breaking the sealed tubes open and handing the Presidential Coins out individually. But anyone who does would be an absolute fool. So, to keep that from happening we are giving away a free Presidential Dollar Coin with each Ballistic Roll. That way everyone can still examine and show off the individual free coin without breaking the seal on the valuable Ballistic Rolls," Milton said.

"Just think if you had saved the Eisenhower Dollar Coins. Right now you'd be tempted to cash them in for a huge jackpot.

Now that this free coin giveaway is being so widely advertised, people are practically clawing each other's eyes out to beat the order deadline for the sealed Ballistic Rolls," said Milton.

Beginning today at 8:30 a.m., the National Order Hotline opens to the public for only 7 days. Readers must dial **1-800-239-3675**. If the lines are busy, keep trying.

"We have to put limits on dealers. But everyone else who calls should be able to get what they need," Milton said. ■

# HERE'S HOW TO GET YOUR FREE COINS

## Claim Authorization SR1674

Readers have 7 days to call the toll free National Order Hotline at **1-800-239-3675** beginning at 8:30 a.m. today.

The World Reserve has just announced that it is also giving away the Presidential Dollar Coin to everyone who beats the 7 day order deadline for each Ballistic Roll. The crystal clear sealed Ballistic Rolls are being released from the vault in these impressive vault bricks for the special fee of just $98 plus shipping. That's a whopping 425 grams of coins in all.

Those who miss the deadline will be turned away and required to wait for future announcements authorized by the World Reserve Monetary Exchange in this or other publications.

THE INCREASE IN COLLECTIBLE VALUE OF CERTAIN PRIOR ISSUES OF U.S. COINS AND CURRENCY DOES NOT GUARANTEE THAT CURRENT ISSUES WILL ALSO INCREASE IN VALUE. THE WORLD RESERVE MONETARY EXCHANGE IS NOT AFFILIATED WITH THE UNITED STATES GOVERNMENT OR ANY GOVERNMENT AGENCY. OH RESIDENTS PLEASE ADD SIX PERCENT SALES TAX AND SORRY NO SHIPMENTS TO MA, TN, AND VT RESIDENTS. ALL TRANSACTIONS LESS SHIPPING ARE BACKED BY THE FULL VAULT CONTENTS OF THE WORLD RESERVE MONETARY EXCHANGE WITH A MONEY BACK GUARANTEE UP TO $10,000.00.

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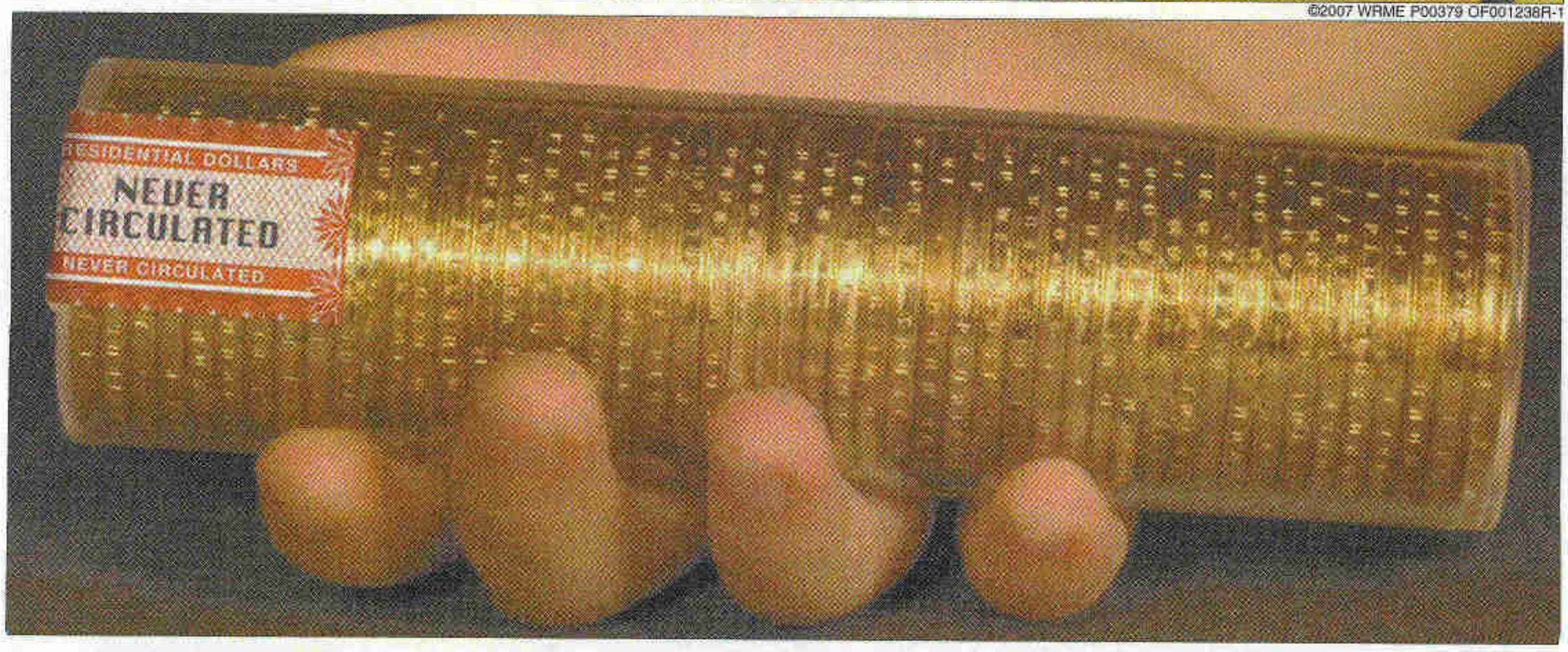
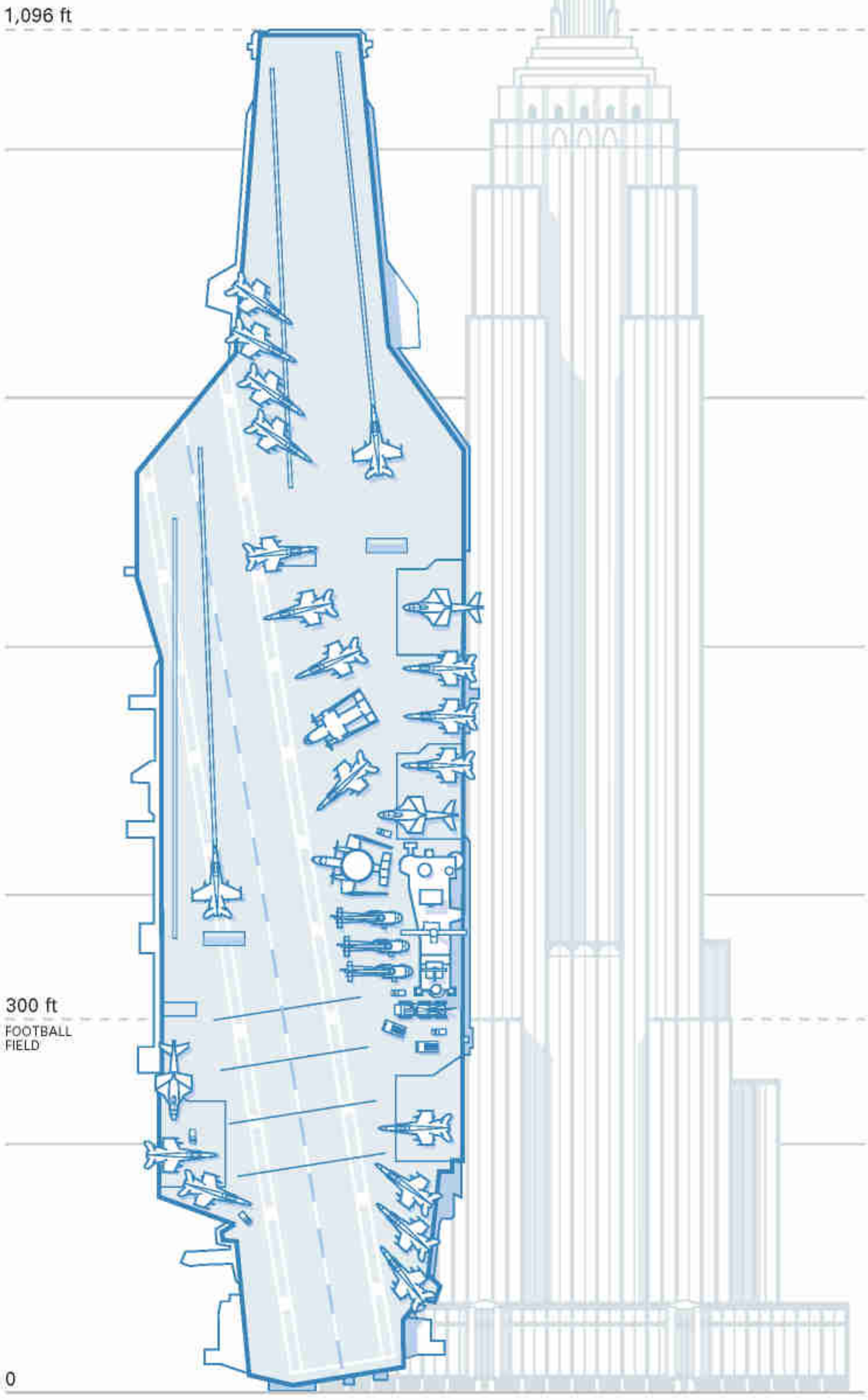


# INSIDE GEOGRAPHIC



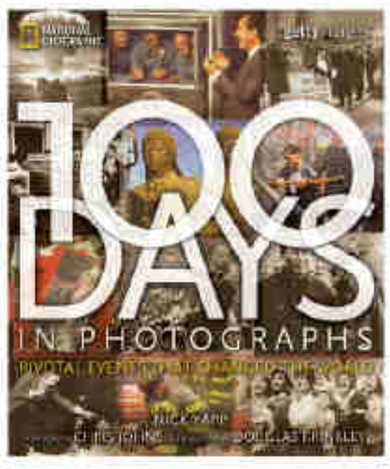

## Supercarrier

The U.S. Navy's newest aircraft carrier—and the crew members who make its work possible—are the subject of *Supercarrier U.S.S. Ronald Reagan,* a two-hour special on the National Geographic Channel. The filmmakers went behind the scenes to see how multimillion-dollar jets are carefully choreographed onto and off the ship's massive deck. They followed the *Reagan's* Capt. Terry Kraft through a typical day and tracked the Empire State Building–size ship from blueprint to battle readiness. *Supercarrier U.S.S. Ronald Reagan* premieres this month on the National Geographic Channel.

### THE SUPERCARRIER AT A GLANCE

- More than 80 aircraft on board
- 5,500 crew members
- Nuclear powered
- Can go more than 20 years without refueling
- Two aircraft can launch and one can land every 37 seconds

## NG Books




**100 Days in Photographs**
National Geographic and Getty Images have delved into their archives to find some of the most important pictures made on some of the most important days in history. The images they found—many of which have never been published before—are featured in the new book *100 Days in Photographs.*

With text by Nick Yapp and an introduction by GEOGRAPHIC Editor in Chief Chris Johns, the book covers a hundred days of world-changing events including Abraham Lincoln's assassination, the stock market crash of 1929, Nazi Germany's Kristallnacht, and Chernobyl's nuclear meltdown. *100 Days in Photographs* is in bookstores now ($35).

ART: OLIVER UBERTI

# Found! The Last Morgan Silver Dollars

## Amazing Discovery Hidden in Midwest Farm Cellar

**Indiana.** A farmer in America's heartland recently cashed in his long-forgotten savings, hidden away for decades in a dusty crate in his cellar—a hoard of the last Morgan Silver dollars minted by the U.S. Treasury before they ceased production for good, in 1921.

Originally purchased from a local bank for face value, the farmer had tucked them away for his retirement. Now these glittering chunks of silver history, mint-fresh and never placed into circulation, are being released to the public by the FFC.

*Originally U.S. Silver Dollars were minted and stored in 1,000-coin canvas bags by the Mint.*

### Survival Against All Odds

By all rights these silver dollars should have been destroyed decades ago. Government silver melt-downs, including the 1918 Pittman Act, which alone destroyed 270 *million* Morgans, have decimated supplies. Millions more were called in by the government and melted for their silver content between 1921 and 1965. Today private hoards account for virtually all the surviving coins. And of those, only a fraction survive in the Brilliant Uncirculated condition highly coveted by collectors.

### Prized Last Year Coins

These last year 90% pure silver beauties still dazzle with their Mint luster and heft. Weighing in at 26.73 grams with a diameter of 38.1mm, they are the largest American silver coins ever to circulate. Struck from silver mined from the western Mother Lode, they are the legendary coins that built the West. Master engraver George T. Morgan fashioned a radiant profile of Lady Liberty and a majestic eagle as symbols of our nation's strength and prosperity. Today, the long-gone Morgan silver dollars are among the most sought-after coins in America.

### Hot Silver Market, Hot Silver Value

Silver prices have jumped over 200% in the last two years fueling the frenzy among avid collectors, investors, and the 130 million new collectors created by the U.S. Mint's highly successful state quarters program.

Today, the market is hot for Silver coins in any condition. This same 1921 Morgan Silver Dollar currently sells elsewhere in circulated, worn condition for $50 apiece. But while supplies last you can get this original *Mint Condition* Uncirculated 1921 Silver Morgan for as little as $23 each, in quantity!

### Money-Back Satisfaction Guarantee

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*Brilliant Uncirculated* **$29.50** *plus S&H*

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# FLASHBACK

**Big Fun** He was there to cover Tonga's King Taufa'ahau Tupou IV taking the throne, but the late NATIONAL GEOGRAPHIC writer and photographer Luis Marden also caught the monarch taking to the waves. "Riding a king-size board, the 325-pound Taufa'ahau surfs in Pacific combers," noted this photo's caption in the March 1968 magazine. Low calories, Marden observed, were not of high importance in Tonga. "Sauntering youths call out to a passing beauty, *'Foi'atelolo, ta ō mu'a mata māhina hopo!'* (O fat liver full of oil, let us go and watch the moonrise!)," he wrote. "The liver of a baked pig is the choice morsel reserved for chiefs, and so fond are the Tongans of fat and oily food that any right-minded Tongan girl is enormously pleased at such flattery." *—Margaret G. Zackowitz*

**Flashback Archive** Find all the photographs at **ngm.com.**

PHOTO: LUIS MARDEN, NATIONAL GEOGRAPHIC IMAGE COLLECTION

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